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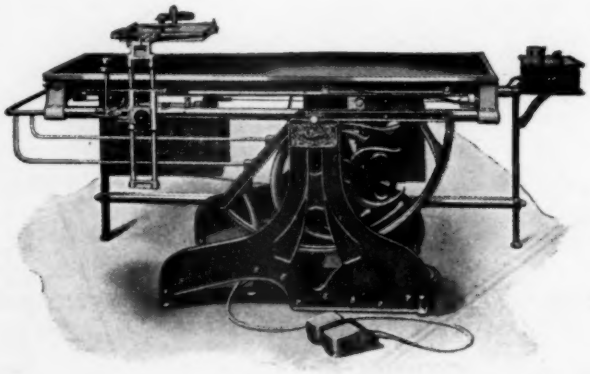

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

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VOL. VII (NEW SERIES) OCTOBER, 1920 No. 10

INSTANTANEOUS RADIOGRAPHS OF THE HUMAN HEART AT DETERMINED POINTS IN THE CARDIAC CIRCLE

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MADISON, WISCONSIN

INTRODUCTION

IMPROVEMENTS in *x*-ray apparatus, allowing more rapid exposures to be made, and the development of methods for making accurate determinations of cardiac area and volume, open up interesting and important fields for study in reference to cardiac movements, and determinations of the extent and character of contraction. Bardeen [1] has shown by patient and thorough researches that it is possible to determine the diastolic volume of the heart from the *x*-ray shadow area with an error of less than 10 per cent. The determination of the diastolic size and shape offers no serious technical difficulties, because it is the phase of the heartbeat which gives the greatest shadow, and the exposure may be prolonged to include several cardiac cycles. Determination of the area of the shadow and volume of the heart in phases of the cycle other than diastole offers two considerable technical difficulties; first, the exposure must be sufficiently short to include only the particular phase desired, and second, there must be some means of determining accurately the particular phase of the cycle in which the exposure is made. It is the purpose of this paper to describe a method by means of which these difficulties have been overcome, and to give briefly some of the results which have been obtained by its use.

METHODS

Efforts to obtain satisfactory *x*-ray shadowgraphs of the heart sufficiently rapid to include only a single phase of the cardiac cycle, and sufficiently distant from target to film to prevent undue distortion, were made by one of the present authors in collaboration with Dr. Dardeen in 1917. At this time we succeeded in obtaining satisfactory results with the full output of a 10 K.W. transformer, with a working distance of two meters, and an exposure of approximately one-twentieth of a second, using a gas tube selected from a considerable number at our disposal. The method of determining the phase of the cycle in which the exposure was made was a modification of that employed by Huismans,[2] in which a tracing of the carotid pulse was made and the instant of discharge of the transformer marked on this tracing by an electromagnetic signal. In order to obtain

an exposure at a determined point in the cardiac cycle, the carotid tambour made an electrical contact at a fixed period in its excursion. A subsequent exposure was usually made on the same film by a second closure of the current through the transformer by means of a key which was closed by a falling body. The falling body was released by the first exposure, and the period from the first to the second closure could be timed by varying the distance through which the body had to fall before closing the second contact. This method was used in estimating cardiac output in man by determining the area of the systolic and diastolic shadows, and calculating the difference in the volume of the heart at these two phases. A brief discussion of this method with a statement of results is given in Dr. Bardeen's [3] paper. We have abandoned this method for the following reasons: (1) the great difficulty of maintaining a gas tube in the proper condition for rapid exposure; (2) the inaccuracy of utilizing the carotid pulse as a means for determining the incidence of exposure in the cardiac cycle, and (3) the difficulty of accurately following two outlines of the heart when superposed on the same film. The impulse in the carotid artery occurs an appreciable period of time after the beginning of cardiac systole, a period combining that of rising tension in the ventricle (presphygmic period), and in addition the time of transmission of the aerial wave from the base of the aorta to the artery in the neck. Both of these factors show slight variation in the same and may differ markedly in different individuals, and are difficult to estimate accurately.

The method that we are at present using provides for the accurate determination of the incidence of exposure by recording a simultaneous electrocardiogram. The work of a number of investigators [4] has shown that the electrocardiogram is an accurate index of the onset and duration of ventricular systole. The onset of the R complex of this curve precedes ventricular systole, as measured by the initial rise of intraventricular pressure, by a few hundredths of a second, and is practically coincident with the beginning of the first heart sound. The end of the T wave likewise indicates the end of ventricular systole as marked by the closure of the semilunar valves and the occurrence of the second heart sound. The end of the T wave of the electrocardiogram coincides with the onset of the second heart sound with a plus or minus variation of approximately one-hundredth of a second. The determination of the incidence of exposure by the electrocardiogram has two great advantages over other methods; first, that the two most important events of the cycle, the beginning and end of ventricular systole, are sharply indicated, and second, that inertia or lag in the instrumental recording is negligible. An electrocardiogram is made by the usual method, connections being made with the subject by electrodes on the right wrist and left ankle. The galvanometer and the *x*-ray apparatus are in different rooms and connection is made by wire in conduit. The leads from the galvanometer come into the *x*-ray room at right angles to the aerial wires in order to reduce induction. The onset and duration of the discharge of the transformer in making the *x*-ray exposures is marked on the galvanometer record by a series of vibrations (Fig. 2) resulting from induction between the aerial wires and the wires leading from the subject to the galvanometer. The amount of this induction can be varied by varying the position of the wires until there is sufficient to record, but not enough to throw the galvanometer thread out of the field. A telephone connection between the *x*-ray and electrocardiographic laboratories made coordinated operation possible.

A regular Coolidge 10 milliampere radiator tube is now being used for all exposures, and this receives the full output from an eight kilowatt "Standard" transformer. With a filament current of 4.8 amperes there is a spark gap of about seven inches. We have made no attempt to measure the milliampere discharge. The distance from the target to plate is one meter, the period of

exposure about one twenty-fifth (0.4) seconds. Distortion of the shadow area is corrected by measuring the distance from the film to the target and estimating the distance from the heart by measuring the antero-posterior diameter of the chest and taking one-third of the distance from the anterior surface. The anterior surface of the chest is brought as closely as possible to the film.

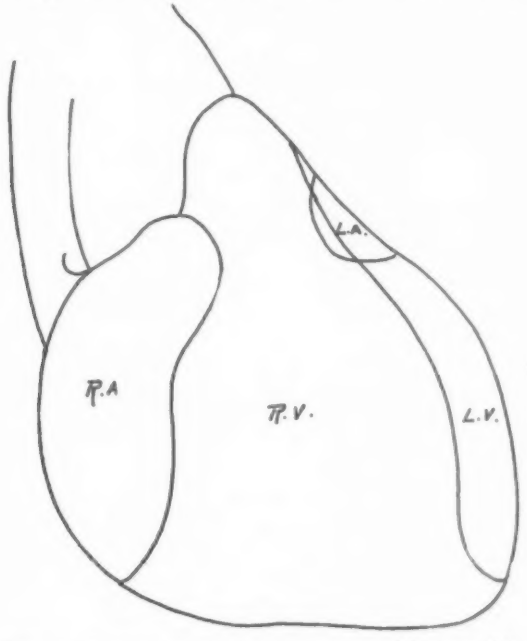

FIG. 1. OUTLINES OF CHAMBERS IN HUMAN VENTRICLE. Anterior aspect.

Duplitized films are used between two reinforcing screens. The exposures are timed either by circuit breakers or fuses. Circuit breakers will work as low as one-fiftieth second, and at any setting are accurate in their timing of successive exposures, as we have found by repeated measurement of the duration of discharge of tubes by a moving film and tuning fork. Exposures as timed by fuses are much less constant. With a primary current of 220 volts and 50 amperes, a 6 ampere fuse will break on an average in about one-twentieth of a second, but there is considerable variation.

In order to obtain exposures on different films within the same heart cycle, we have devised a casette-changing mechanism allowing of two exposures within a period of eight hundredths of a second. One casette is in a carriage attached to heavy springs and is held in place in the field of exposure by a catch. The other casette is immediately in the rear of this and is pressed against it by the spring, a lead plate intervening to prevent exposure of the film in this casette during the first flash. The first closure of the primary circuit through the transformer makes the exposure of the first film, which is terminated in approximately one twenty-fifth of a second by the release of the circuit breaker. The movement of the solenoid arm of the circuit breaker also releases the carriage to which the first cassette is attached, and this is suddenly jerked out of the field, the second casette at the same time moving forward into the field to take its place. As the carriage containing the first casette moves out of the field of exposure, it closes an electrical switch which connects a second circuit through the primary containing either a second circuit breaker or a fuse, and the exposure of the second film results. The whole apparatus is attached to a heavy steel frame which prevents vibration.

For the placing of exposures at desired points in the heart cycle, the method we have adopted after trial of several is simple manual closure of a key while listening to the heart sounds through a stethescope. The two principal heart sounds mark important events in the cardiac cycle. The first begins at the onset of ventricular systole when the ventricle begins to contract down upon its full compiement of blood. This phase of the cycle, usually designated as the period of rising tension, or presphygmic period, continues for approximately seven hundredths of a second in the human heart, and during this time the heart volume remains unchanged and represents the full diastolic size of the heart. The beginning of the second sound represents the end of the period of outflow or emptying of the ventricle, and the heart again retains the same volume for approximately the same length of time as following the first sound, and this period, the postsphygmic, represents its smallest or sys-

tolic volume. Two exposures made in the same cycle, one coincident with the onset of the first, and the second coincident with the onset of the second sound, give a basis for the determination of the volume of the heart when it contains the greatest and the least amount of blood, and the difference between these must be the volume of blood pumped at that beat. This figure, multipled by the number of beats per minute, represents the minute volume output of the two ventricles.

With a regular heart rhythm, it is surprisingly easy to make the two exposures at the time of the two heart sounds by simple manual closure of a key while listening to the sounds. It is also possible voluntarily to delay closure and have the exposure come at other times, the incidence in every case being marked by the simultaneous electrocardiographic record. One gets the "swing" of the rhythm while listening and the key closure becomes a matter of anticipation and not of reaction. We have also worked with a sound amplifying device which closes the primary of the *x*-ray transformer automatically with each heart sound, but up to the present time we prefer the manual method because of its simplicity and selectivity.

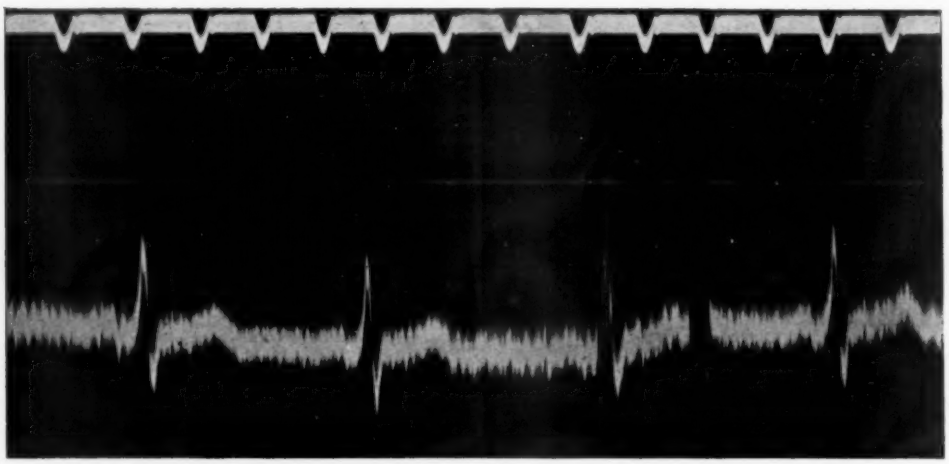

FIG. 2. ELECTROCARDIAGRAM FROM LEAD II, SHOWING INCIDENT OF *X*-RAY EXPOSURES.

RESULTS

The data that we have obtained up to the present time by the use of this method is associated with several lines of study. We wish to report at the present time only certain observations concerning the change in size and shape of the normal human heart during the several phases of its cycle, reserving for subsequent communications observations of the cardiac volume output in man and experimental animals under normal and pathological conditions. The parts making up the outline of the *x*-ray shadowgraphs of the human heart are shown in Fig. 1. It is seen that this outline is made up by all the chambers of the heart, the left auricle however being included only to a very limited extent.

Studies of the change in the shape of the human heart during the various phases of the cardiac cycle have been made in ten young adults with normal hearts. In all of these, systolic and diastolic exposures were made in the same cycle. Other sets of two exposures were also made at other times in the cycle within short periods and under similar conditions. All exposures were made during the phase of normal inspiration, and in the standing position.

In Fig. 2 is shown an electrocardiagram from one of the subjects showing two discharges of the *x*-ray transformer, one occurring within the R complex and hence occurring during the presphygmic period of the ventricle, the other at the end of the T wave and hence at the end of ventricular systole.

In Figs. 3 and 4 the radiographs from these discharges are reproduced and these are superposed in Fig. 5 to bring out the difference in the borders of the heart. Superposition may be accurately made with the rib outlines

The observations that we have made up to the present time on the normal human heart enable us to make certain statements as to the normal movements of the human heart.

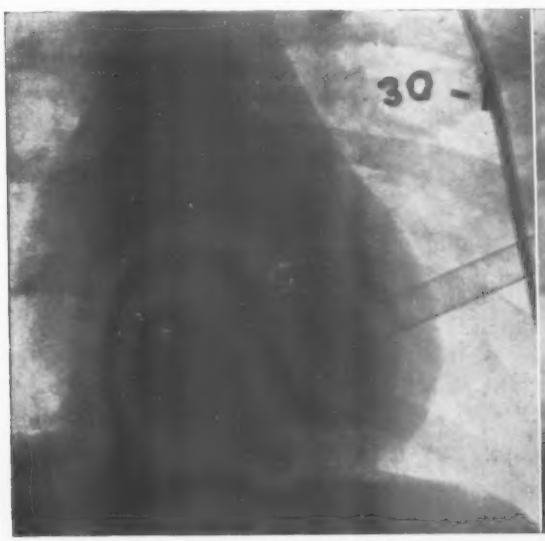

FIG. 3. RADIOGRAPH OF HUMAN HEART DURING FULL DIASTOLE.

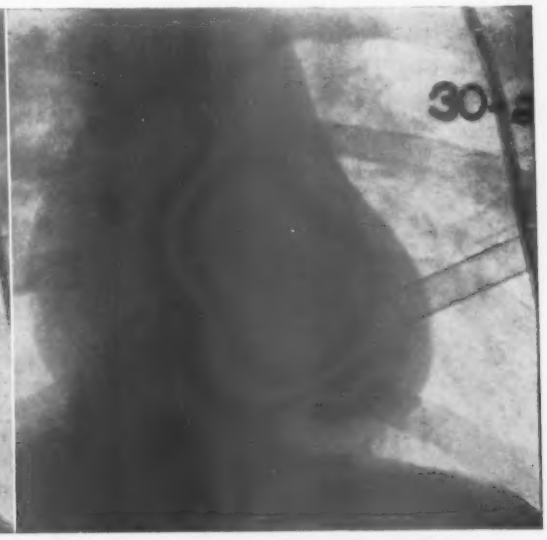

FIG. 4. RADIOGRAPH OF SAME HEART SHOWN IN FIGURE 3 DURING HEIGHT OF SYSTOLE.

and the outlines of the aluminum capsule which replaces the usual stethescope bell and which may be seen projecting from the left of each figure.

In Figs. 6 and 7 the outlines of two hearts in different phases of the cycle are shown. The radiographs were made as described above and the outlines transferred to a single diagram. The position of the individual exposures, as determined from the electrocardiographic records, are indicated on the diagrammatic electrocardiogram. In Fig. 6 the first exposure was made at the end of systole of the ventricles, the second in mid-cardiogram. In Fig. 7 the first exposure was diastole, and the third immediately before contraction of the auricle as indicated by the auricular wave ("P" wave) of the electrocardiogram. In Fig. 7 the first exposure was made immediately before auricular contraction, the second during the presphygmic period of the ventricle, the third near the middle of the period of ventricular outflow, the fourth at the end of the period of ventricular outflow, and the fifth in mid-diastole.

The decrease in size of the cardiac area during systole may involve any of the outlines, but does not usually involve all. The

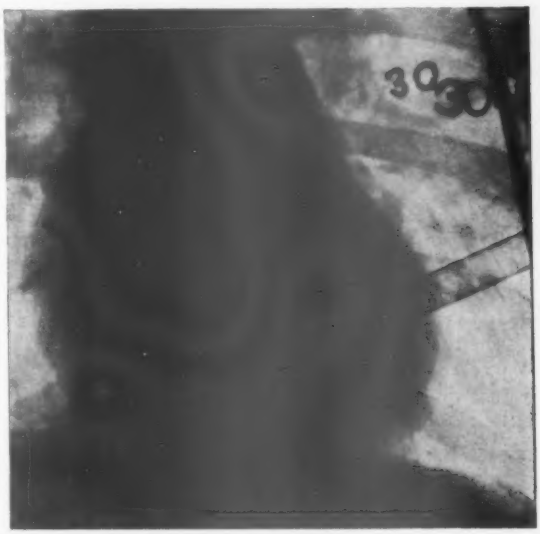

FIG. 5. SUPERPOSITION OF FIGURES 3 and 4, SHOWING CHANGE IN SIZE AND OUTLINE OF HEART AS A RESULT OF CONTRACTION.

outline corresponding to that of the right auricle varies least in position, while the left

ventricular outline, particularly toward the apex, is the margin which undergoes as a rule the greatest movement. The border of the right ventricle nearly always shows a definite ascent, and there is usually, but by no means always, a descent of the base.

The rule seems to be a slight increase in the right auricle outline during systole, due to the collection of blood in this chamber at this time; but this is not invariable, and the border may actually reduce during systole. The same heart may behave differently at different times, at times reducing certain borders, at other times other borders. If one compares the actual shape and sizes of the diastolic shadows, they agree closely, and this is also true of the systolic shadows. It would seem, therefore, that the differences noted may be due to slight changes in position of the whole heart rather than to differences in character of contraction.

The part of the left ventricular border affected may likewise vary. Usually the maximum change is at or near the apex and decreases upward, but the reverse may be seen. The movement of any one point on the left border may give an entirely erroneous idea as to the extent of contraction of the heart. The change in the greatest transverse diameter may therefore give little accurate indication of the extent of contraction. What may be regarded as a typical cardiac contraction may be described as follows: When the auricles contract, the right auricular border decreases slightly, and there is a corresponding enlargement showing along the lower border of the left ventricle and right ventricle. The apex moves about 1 mm. to the left and the heart becomes slightly more elongated from base to apex. How much effect the auricular systole has in adding blood to the ventricular complement is impossible at present to say, but it is certainly very small, and in many instances cannot be made out. As the ventricles contract, the right auricular border enlarges slightly and extends outwards slightly more than immediately before auricular systole. The bases

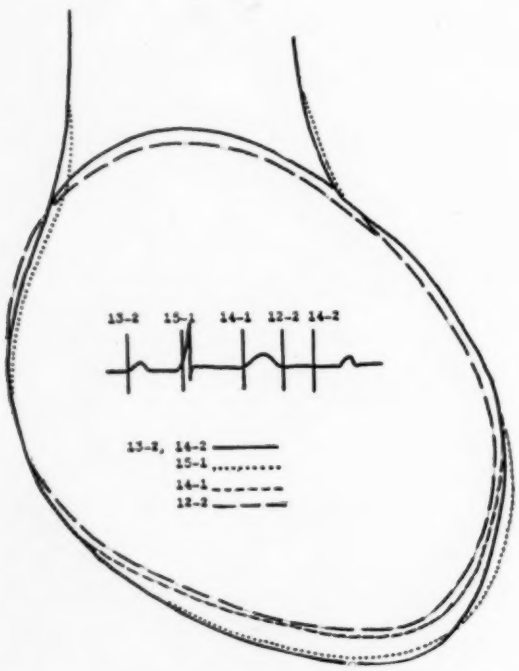

FIG. 6. CHANGES IN OUTLINE OF HUMAN HEART DURING CONTRACTION.

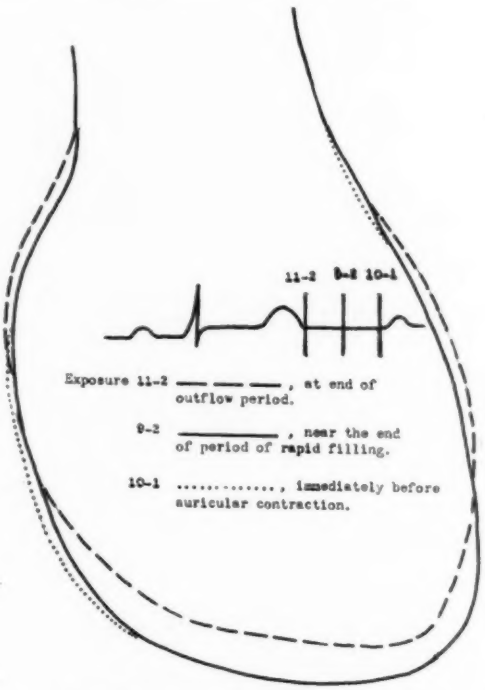
11-2 9-2 10-1
Exposure 11-2 , at end of outflow period.
9-2 , near the end of period of rapid filling.
10-1 , immediately before auricular contraction.

FIG. 7. FILLING PERIOD OF HUMAN VENTRICLES. The three *x*-ray exposures were made as shown by electrocardiograph record.

of the ventricles descend a few millimeters and the whole heart shadow becomes more globular in outline. The apex moves upward and to the right, the right ventricular border moves towards the base and the left ventricular border to the right. Succeeding the period of outflow the ventricles fill, and this filling appears to be somewhat more rapid early in diastole than later. Thus in a comparison of the full diastolic shadow in one case with the shadow 0.05 sec. after diastole begins there was a difference in volume of 32 c.c. The normal difference in diastolic and systolic volume in this heart was 42 c.c., and the total period of diastole about 40 sec. Thus about one fourth of the blood has entered in the first one eighth of the diastolic period. In another determination 26 or 83 c.c. of blood or about one third had entered in the first one fourth of the diastolic period. In another case with a slow heart (pulse of 60) and a large output per beat (107 c.c. average of two determinations), nearly half of the filling occurred by the end of the first one seventh of the diastolic period. The major part of ventricular filling seems to occur therefore almost as rapidly as the emptying. In one determination a systolic shadow (No. 39) made 0.10 sec. after the beginning of systole differed by only 6 c.c. in volume from a similar shadow 0.10 sec. after the beginning of diastole. In this case the systole had a duration of 0.27 sec. diastole 0.38. The normal output per beat was 46 c.c.

SUMMARY AND CONCLUSIONS

A method is described for making rapid *x*-ray shadowgraphs of the human heart with a casette-changing mechanism allowing two exposures within the same cardiac cycle.

By recording a simultaneous electrocardiogram the exact incidence of these exposures in the cardiac cycle is determined, and their position may be quite accurately chosen by listening to the heart sounds and closing a key by hand.

The changes in shape and size of the normal human heart during its cycle are described so far as we feel justified on the basis of observations made up to the present time. The most important points that we feel are evident at present are the following:

1. The movement of no single border of the heart is an accurate index of the extent of its contraction. The whole outline is necessary for such estimation.

2. The mechanism of ventricular filling would seem to be very similar to that which physiological experimentation has constituted in the dog,[5] especially in that the major part of ventricular filling occurs shortly after the ventricle goes into relaxation and is in large part completed before the subsequent auricular contraction, systole of this chamber playing little rôle in adding blood to the ventricles.

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CARDIOSPASM

By P. F. BUTLER, M.D.

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THE study of spasm of the cardiac end of the stomach and its later development, cardiospasm, does not receive the attention that this distressing condition warrants. Spasm of cardia is not as rare as generally believed; it can be demonstrated in many of the cases where a lesion of the upper stomach is present. True cardiospasm, however, is not a common condition. Most of the literature refers to one or two cases observed by different men. Smithies, however, reported sixty-three cases in seven years, in a very thorough paper.[1]

Spasm of the cardia is secondary to an organic lesion, and the latter may be in the esophagus, stomach, duodenum, gall-bladder, appendix or pelvis. I have followed two well marked cases and seen them cleared up for two years—as long as they could be followed —by the removal in each case of a chronic appendix.

If spasm of the cardia persists long enough it results in first a temporary and later a permanent obstruction. The latter condition is accompanied by hypertrophy of the cardiac sphincter and the lower portion of the esophageal musculature, diffuse dilatation of the esophagus, kinking and tortuosity of the esophagus and later by obstruction. There may be great dilatation and retention of four or five meals without visible pressure symptoms on the other thoracic viscera, because the slow development gives time for the process of accommodation. The onset is most often gradual and the condition usually is present for two or three years before complaint is made. It is most often found in early adult life, and in males slightly more often than in females. It may also be congenital or at least occur very early in life. Stenosis may result from persistent spasm over a period of years, followed by its accompanying sequelae, malnutrition, constipation, dizziness, anemia and eventually death.

The clinical picture of cardiospasm reveals absence of pain, difficulty in swallowing (more marked with liquids), early sense of fullness while eating or drinking, copious regurgitation (often propulsive), loss of weight (from starvation), and constipation (from lack of fluids). There is never the picture seen in carcinoma, of toxemia from absorption. The vomitus shows undigested food, no blood or gastric elements, long retained food.

Roentgen examination gives a typical picture; dilated esophagus, perfectly smooth in contour, coming down to a point at its lower end and long retained barium. In carcinoma there is little dilatation above the obstruction because of the rigid, infiltrated walls, and the outline at the constriction is ragged; in addition the carcinomatous obstruction passes only fluids, while the cardiospasm takes solids better. The spasm may be intensified by the use of irritating substances, as ground pineapple, or by very cold drinks, and may often be relieved by atropine. Stricture following trauma (foreign bodies, caustics, etc.) rarely is seen so low down, and furthermore has a definite history. Syphilis, of course, may imitate every condition, but is very rare in this location and also offers other positive diagnostic evidences.

The case presented is one of congenital cardiospasm in a man of thirty-four; he has had difficulty in swallowing as far back as he can recall. He was admitted to the service of Dr. Libby of the Boston City Hospital for pneumonia and passed successfully through it. During convalescence he was examined in the roentgen laboratory, and ordinary chest plates were made, which revealed the condition seen in Fig. 1. A fluoroscopic examination was made the follow-

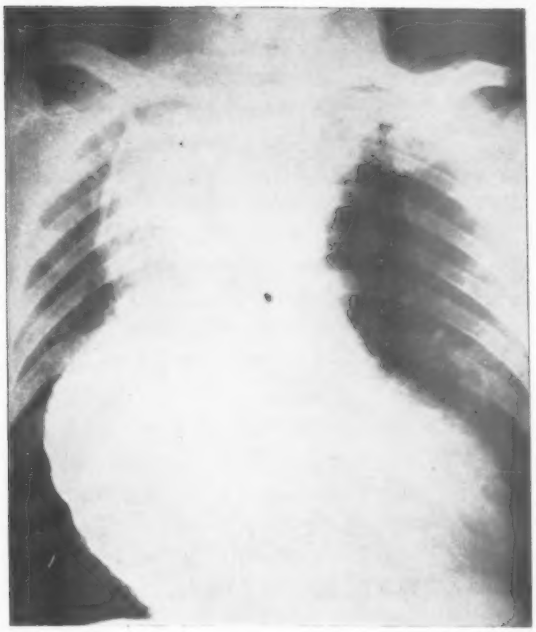

FIG. 1.

FIG. 3.

FIG. 2.

ing day to investigate the unusual appearances seen on the plates. The heart was normal in size and not displaced. The excursions of the diaphragm were normal on both sides. There was no pulsation in the tumor-like masses in the upper and lower chest. A swallow of barium was given and with much difficulty was followed on a tortuous, wandering path down to the cardia; it first disclosed a fluid level in the third interspace, after which it went off to the right, then straight backward, then to the left and next downward and forward to the level of diaphragm, sometimes through the center of the opaque area and sometimes along its sides. More barium was then given and it soon became apparent that we were dealing with a greatly dilated esophagus partially filled with food and liquids.

About this time the patient regurgitated about a quart of fluid and immediately more barium mixture was given; this filled the canal quite thoroughly and the plates shown in Figs. 2 and 3 were taken. Three pints of the mixture were given, with no apparent distress. Twenty-four hours later there still remained about an ounce of barium mixture in the lower esophagus, the remainder having passed on to the large bowel. At a second examination, after the patient had fasted for about ten hours, the esophagus had diminished considerably in size and

showed a fluid level at the junction of its lower and middle thirds. The measurements at this time were 6 cm. on a level with the arch of aorta, 5½ cm. in its middle third and 6½ cm., about two inches, above the diaphragm, from where it narrowed down toward the cardia. This man, by the way, was well developed and showed no ill effects from the lesion.

1. SMITHIES, F., *J. Roentgenol.*, 1919, ii.

CASE OF XANTHOMA SHOWING MULTIPLE BONE LESIONS

By A. S. MERRILL, M.D.

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THIS rare disease was first described by Addison and Gull in Guy's Hospital Reports of 1851. After many years' careful study the etiology is still in question.

It is characterized by the formation of plates or nodes of a yellow or yellowish white color in the corium, and has attracted the greatest attention as a subject for dermatological study, and is usually so classified.

It is classified as to form as (1) xanthoma planum, and (2) xanthoma nodosum; as to location as (1) xanthoma palpebrarum, and (2) xanthoma multiplex. When accompanied by glycosuria it is known as xanthoma diabeticorum. The planum and nodosum varieties are regarded as different stages or degrees of the same condition. Török considers xanthoma palpebrarum as a distinct clinical entity.

In xanthoma multiplex the nodes or plaques occur on cutaneous surfaces and sometimes are found on mucous and serous membrane. It is often associated with disorders of the liver. Galloway suggests that morbid metabolic changes causing inadequate function of the liver play an important part in the disease. Chauffard, Laroche, and Thibierge, comparing the condition to gout, suggest that it bears the same relation to a cholesteremia as gout with tophi formation to an excess of uric acid in the serum. The blood in this case showed a great increase in cholesterol.

Sometimes it appears hereditary, and congenital cases have been reported. It appears to be a disease of early life.

Concerning the morbid anatomy and pathology, there is a diversity of opinion. In the corium are found large multilocular connective tissue cells filled with fat. A formation of new, and a destruction of pre-existing fibrous tissue occur. The theory of a neoplastic appears to prevail over that of an inflammatory origin.

In rare cases the lesions are found on mucous and serous membranes, in the bile ducts, and arteries. The general jaundice-like pigmentation has been attributed to the partial obstruction of the bile-ducts by nodules. They have been found in tendon sheaths, the heart and the liver. On the extremities the favorite locations are about the joints, the palms and the soles, and the body folds. Morris states that "on the knuckles the growths have sometimes been found connected with the underlying tendons. In some cases they have been attached to the periosteum." MacLeod in his excellent description notes changes about the joints, especially the wrists, where the tumors appeared to be growing from the deep structures such as tendon sheaths or actual bone periosteum. He illustrates his description by a good radiogram showing erosions and irregularity of the bone (ulna) opposite the tumor.

Little has been said concerning the bone lesions in this disease, and in the descriptions of the distributions of the lesions the bones have been practically omitted. The

x-ray study is especially meager. I believe the only reference to these lesions accompanied by an *x*-ray description is that of MacLeod in the *British Journal of Dermatology* of November, 1913.

From the diversity of structures involved, and the histological nature of the morbid changes, it seems only reasonable that the bones should not escape and quite logical that they might share in the pathological picture.

Considering the nature of the process as described in other tissues, one might reasonably expect the bones, if involved, to exhibit areas of defect in structure representing the replacement of normal tissue by the abnormal tissue of pathological formation. The appearance of the bones confirms this suspicion. The lesions appear purely destructive, and the assumption is that the normal structure has been locally destroyed and replaced by the characteristic tissue of the process forming the dense nodules felt intimately connected with the bones.

The findings in the radiogram must be differentiated from gout, arteriosclerosis, multiple cysts, osteomyelitis, tuberculosis and syphilis. The first two especially present radiographic appearances which are practically impossible to distinguish by plate alone from those of this disease.

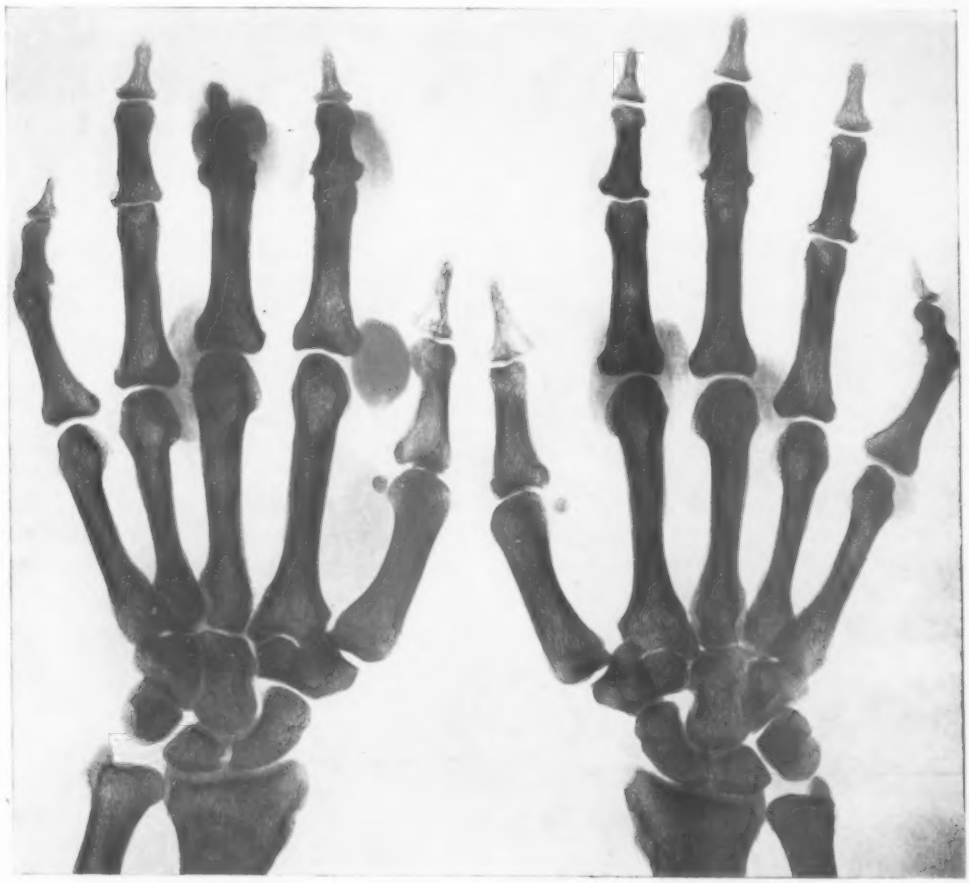

FIG. 1. SYMMETRICAL LESIONS IN 1ST AND 2ND PHALANGES OF THUMBS, 2ND PHALANGES OF FINGERS, AND ULNAE AND RADII.

From gout the lesions appear to be differentiated to a degree by the absence of involvement of the joint surfaces. Arteriosclerosis is seen as a rule at a later age, and evidence of calcification may be found in the arteries. Multiple cysts and osteitis fibrosa involve deeper bones with cyst formation,

abnormal trabeculation, thinning of the cortex, and often expansion of the weakened area, sometimes with spontaneous fracture. Osteomyelitis presents evidence of regeneration and bone repair. Tuberculosis may usually be distinguished by its origin in or near the epiphysis with rarefaction and little evidence of regeneration.

The patient in this case was a young white woman, twenty-seven years of age, of Canadian birth, unmarried, whose only occupation had been housework.

The family history presents the interesting fact that a brother had the same kind of lesions over fingers and body. Nine other brothers and three sisters were not affected, nor was either parent.

She had diphtheria at the age of seven, and "rheumatism" at twelve. Her general health has been fair. Recently she has been troubled by frequent nausea and gastric discomfort (but no pain) one or two hours after a heavy meal, accompanied by headache in frontal, temporal and occipital regions. Vomiting relieved all these symptoms. Sometimes the gastric discomfort would be relieved by exercise. She never vomited blood or passed bloody or tarry stools. Within the last few years she has complained of palpitation and some dyspnea after exertion. No pulmonary symptoms were present.

Examination of the heart was negative. The genito-urinary and neuro-muscular examinations were negative. Her usual weight remains stationary.

At about the age of seven, a few light yellow nodules appeared over the elbows, knees, and knuckles; not painful or itchy. These gradually increased in size, while new ones appeared on the body. During a period of twenty to twenty-one years they reached their present size and distribution. They were never painful or sensitive. Some of them near the joints of the fingers interfered somewhat with motion as their size increased.

Physical examination showed an eruption of papules and nodules of various size over arms, legs, feet, genital region, eyelids and chin. They were very symmetrically distributed over the extremities. With the exception of the gluteal region, the trunk was practically free from eruptions. The main findings were papules that occurred loosely over surfaces where the skin was thick and rich in subcutaneous tissue, such as the gluteal region and the flexer surfaces of the arms and legs; in the latter, including the joints, in size varying from that of a pea to that of a walnut, firm in consistency, of a yellow to brownish color, showing a definite tendency to lobulation. Smaller ones slightly elevated, but well demarcated from the surrounding skin, were of comparatively light color, yellowish red. Many of the larger ones showed a tendency to pedunculation, especially over the elbow joints. Over the fingers and toes were a few small hard tubercles about the phalangeal joints about the size of a pea, covered with practically normal skin, in most places movable, except a few which seemed connected with the underlying bony structure. The papular lesions consisted principally of small flat papules of light yellow color, well elevated, and presented no inflammatory signs. Papules of the eyelids (6 or 7 on upper lids) were about $1 \times .5$ cm. in diameter. In the gluteal region they grouped together and formed large patches, smooth, flat, deep yellow plaques. Scattered around these plaques were many small discrete papules. The largest patch was about 10 cm. in diameter, covering the gluteal region on either side. Smaller plaques were found at the bend of the elbows and knees, comparatively more elevated and of darker color than those of the gluteal region. The patches showed a tendency to peripheral extension. Nodules around the joints were of a rather firm consistency, covered by pigmented epithelium. Over fleshy areas they appeared softer, covered with epithelium of the same nature, some forming large plaques as mentioned. Some of the tumors occurring over the joints were very hard and seemed attached to the bones.

The lesions present in this case were, briefly:

1. Nodules of eyelids.

2. Nodules around joints, hands, elbows, knees, and feet.

3. Flat tumors over soft tissues.

The palms and soles were free.

The interesting features were the different types of lesion: soft and moderately hard, covered by pigmented epithelium, very hard ones covered by normal epithelium suggesting exostoses, marked symmetry, occurrences in locations where there was liability to friction or pressure, absence of joint involvement.

Three months later, report of blood after high fat diet showed tremendous increase in cholesterol. Fat lower than before.

Multiple xanthomata of hand: excision.

Several tumors of left hand excised; one over metacarpophalangeal joint of index finger found to involve extensor tendon which was trimmed down to normal dimension. Joint itself not involved. Three weeks later excision of tumor of left hand and fingers.

FIG. 2. SYMMETRICAL LESIONS IN 1ST AND 2ND PHALANGES 1ST TOES, 1ST PHALANGES 2ND AND 5TH TOES AND 5TH METATARSALS.

Pathological Report.—Elbow: Hard yellow nodular tumor covered with skin and composed on section of spherical firm yellow

nodules 19 x 18 mm., banded together by connective tissue. Microscopic examination showed tumor composed of fibroblasts forming a mass of network and containing many large vacuolated cells resembling endothelial leukocytes. There were notable light spaces between the fibrils which probably contained cholesterin crystals. About these spaces were small collections of giant cells.

X-Ray Report.—In the soft tissues were many nodular enlargements. Underlying several of these superficial lesions was seen a definite abnormality of bone characterized by destruction which in some of the smaller bones was of cystic nature, in larger bones showed irregular surface destruction with partially outlined margins, most noticeable in the phalanges, metatarsals, lower end of fibulae and ulnae. In the knees and elbows where the superficial lesions were less elevated and more movable there was little or no change.

The findings in this case suggest, or rather confirm the previous belief, that this disease is a systemic condition in which many of the body tissues may be involved, of which the predominant skin lesions are only a striking surface manifestation, and in which the bones may share in the process with the other tissues.

The accompanying plates illustrate the bone changes observed.

"X-RAY"

My father is a Doctor Man,
And he does the queerest things;
Finds hooks and eyes and safety pins,
Down little babies' long red lanes.
The "Grown-ups" all have aches and pains,
And sometimes have the queerest names.
He takes *them* in a room that's dark,
And pulls a switch that makes a spark.
He says, "Now steady, hold your breath!"
The spark goes "buz-z-z-z," and he says, "All right!"
And last he asks them "Name and Age,"
And "When they've had a fall."
But now *I'll* tell you,
'Tis very strange to say,
That all this rigmarole is simply called—

X-RAY!

HELEN ASHBURY.
[Age twelve years.]

UNFILTERED AND FILTERED X-RAY DOSAGE

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THE standard of all roentgen ray dosage is known as the erythema dose; in other words, the quantity of roentgen ray necessary to produce an erythema of the skin in from ten to fourteen days after exposure.

UNFILTERED X-RAY DOSAGE.

The amount of radiation reaching the skin of the part exposed is determined by four fundamental factors: the voltage, expressed as K V or kilovolts; the milliamperage or current, expressed as M A or milliamperes; the time, expressed as T in minutes, and the distance, expressed as D in inches from the target of the tube to the skin. Voltage, or K V, is very often expressed in the number of inches between the spark gap terminals which relatively correspond to the number of kilovolts. The actual determination of the spark gap is obviously just the amount of pressure or voltage that gives a spark across the terminals without the tendency to arc, and which, at the same time, maintains the milliamperage desired in the tube.

The analysis of these four factors necessitated maintaining three of them constant throughout the exposure, and varying the one under investigation. Thus, maintaining 3 Sp G 3 M A for five minutes at a distance of 8 inches produced an erythema in the usual time, ten to fourteen days, over an area of the chest which happened to be covered with hair. The third week after exposure the hair came out and showed no signs of returning at the end of six months. Another area of the chest was exposed and given 3 Sp G 3 M A at a distance of 8 inches for four minutes instead of five minutes. In this area the hair fell out during the third week, and had all returned by the fourth month after exposure.

The latter formula, namely, 3 Sp G 3 M A, four minutes with 8 inch distance, we will call one skin unit. This, then is the dose required for the treatment of ringworm of the scalp, thus insuring the return of the hair, whereas if five-minute exposures were used the hair would not return, and a certain amount of permanent baldness would ensue.

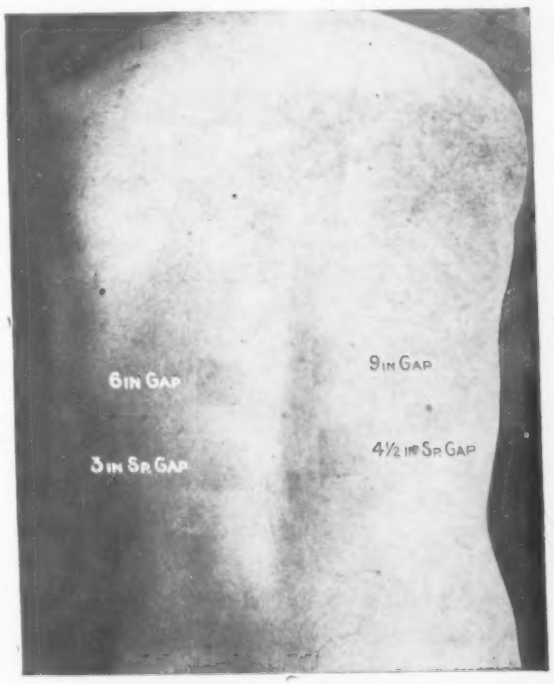

FIG. 1. FOUR AREAS OF PATIENT'S BACK TREATED WITH THE ROENTGEN RAY.

If a pastille were placed 8 inches from the target of the tube and the factors 3 Sp G 3 M A and four minutes time given, the color produced on the pastille would correspond to one on the scale of a Holzknecht

radiometer which, expressed in Holzknecht units, would be 4 H, because Holzknecht readings were originally all made at half distance.

By using the pastilles and a Holzknecht radiometer, it has been found that if you double the time, the voltage, or milliamperage separately, maintaining the other three factors constantly, you will double the dose when the roentgen ray is used without a filter; also that by placing two pastilles, one at full distance, and the other at half the distance from the target of the tube to the skin, the pastille reading at the half distance will be four times that of the one placed on the skin or full distance, therefore inversely to the square of the distance, the same as the law of light.

3 Sp G 3 M A 8 D 2 minutes=½ skin unit
6 Sp G 3 M A 8 D 2 minutes= 1 skin unit
3 Sp G 6 M A 8 D 2 minutes= 1 skin unit
3 Sp G 3 M A 16 D 4 minutes=¼ skin unit
3 Sp G 3 M A 8 D 4 minutes= 1 skin unit

The dose, then, of 1 skin unit, which we have adopted as our standard for unfiltered roentgen ray therapy, would be expressed as follows:

$$\frac{3\text{ Sp G} \times 3\text{ M A} \times 4\text{ minutes}}{8\text{ inch} \times 8\text{ inch}} \text{ or } \frac{3\times3\times4}{8\times8} \text{ or } \frac{3\times3\times\cancel{4}}{8\times\cancel{8}_{2}} = \frac{9}{16}$$

The standard formula for an erythema dose would be:

$$\frac{3\text{ Sp G} \times 3\text{ M A} \times 5\text{ minutes}}{8\text{ inch} \times 8\text{ inch}} \text{ or } \frac{3\times3\times5}{8\times8} \text{ or } \frac{45}{64}$$

In order to prove the actual working of the above formulas, let us take the factor as expressed in the above list.

1. If $\frac{3\text{ Sp G }3\text{ M A }2\text{ minutes}}{8\text{ inch D}\times 8\text{ inch D}}$ is used, what is the dose?

$$\frac{3\times3\times\cancel{2}}{8\times\cancel{8}_{4}} = \frac{9}{32}$$

$$\frac{3\times3\times4}{8\times8} = \frac{36/4}{64/4} = \frac{9}{16} \text{ the standard or one skin unit}$$

$$\frac{9}{32} \div \frac{9}{16} \text{ or } \frac{\cancel{9}}{\cancel{32}_{2}} \times \frac{\cancel{16}}{\cancel{9}} = \tfrac{1}{2} \text{ skin unit}$$

2. With 6 Sp G instead of 3 Sp G, other factors remaining constant, the process would be:

$$\frac{\overset{3}{\cancel{6}}\times3\times\cancel{2}}{8\times\cancel{8}_{4}} = \frac{9}{16}$$

$$\frac{9}{16} \div \frac{9}{16} = \frac{\cancel{9}}{\cancel{16}} \times \frac{\cancel{16}}{\cancel{9}} = 1 \text{ skin unit}$$

3. With 6 M A instead of 3 M A, other factors remaining constant, thus:

$$\frac{3\times\overset{3}{\cancel{6}}\times\cancel{2}}{8\times\cancel{8}_{4}} = \frac{9}{16}$$

$$\frac{9}{16} \div \frac{9}{16} = \frac{\cancel{9}}{\cancel{16}} \times \frac{\cancel{16}}{\cancel{9}} = 1 \text{ skin unit}$$

4. With 4 minutes time instead of 2 minutes' time, the result would be:

$$\frac{3\times3\times\cancel{4}}{8\times\cancel{8}_{2}} = \frac{9}{16}$$

$$\frac{9}{16} \div \frac{9}{16} = \frac{\cancel{9}}{\cancel{16}} \times \frac{\cancel{16}}{\cancel{9}} = 1 \text{ skin unit}$$

5. With 16 inches distance instead of 8 inches and 4 minutes time with 3 M A and 3 Sp G, the result is:

$$\frac{3\times3\times\cancel{4}}{\cancel{16}\times\cancel{16}_{4}} = \frac{9}{64}$$

$$\frac{9}{64} \div \frac{9}{16} = \frac{\cancel{9}}{\cancel{64}_{4}} \times \frac{\cancel{16}}{\cancel{9}} = \tfrac{1}{4} \text{ skin unit}$$

Now let us take the factors as given under 1, but assume that you want to use 3 Sp G 3 M A and 8 inches distance, and desire to give one half of a skin unit and do not know how much time to use.

$$\frac{3 \times 3 \times T}{8 \times 8} = \frac{9}{64}$$

The standard for 1 skin unit is $\frac{9}{16}$; for ½ of a skin unit it would be $\frac{9}{32}$ If, then, $\frac{9}{64}$ represents all of the factors except time, and $\frac{9}{32}$ equals ½ skin unit,

$$\frac{9}{32} \div \frac{9}{64} = \frac{\cancel{9}}{\cancel{32}} \times \frac{\overset{2}{\cancel{64}}}{\cancel{9}} = 2 \text{ minutes' time.}$$

With the factors expressed in 2, what would the Sp G be using 3 M A 2 minutes time at 8 inches distance to produce 1 skin unit?

$$\frac{\text{Sp G} \times 3 \times 2}{8 \times \underset{4}{\cancel{8}}} = \frac{3}{32}$$

$\frac{9}{16}$ = 1 skin unit, therefore,

$$\frac{9}{16} \div \frac{3}{32} = \frac{\overset{3}{\cancel{9}}}{\cancel{16}} \times \frac{\overset{2}{\cancel{32}}}{\cancel{3}} = 6 \text{ Sp G}$$

With the factors expressed in 3, what would the M A be using 3 Sp G for 2 minutes time and 8 inches distance to produce 1 skin unit?

$$\frac{3 \times \text{M A} \times 2}{8 \times \underset{4}{\cancel{8}}} = \frac{3}{32}$$

$\frac{9}{16}$ = 1 skin unit, therefore,

$$\frac{9}{16} \div \frac{3}{32} = \frac{\overset{3}{\cancel{9}}}{\cancel{16}} \times \frac{\overset{2}{\cancel{32}}}{\cancel{3}} = 6 \text{ M A}$$

With the factors expressed in 4, at what distance would it be necessary to place the patient from the target of the tube to produce 1 skin unit, using 3 Sp G 3 M A 4 minutes time?

$$\frac{3 \times 3 \times 4}{D \times D} = \frac{36}{D \times D}$$

$\frac{9}{16}$ = 1 skin unit, therefore,

$$\frac{36}{D^2} \div \frac{9}{16} = \frac{\overset{4}{\cancel{36}}}{D^2} \times \frac{16}{9} = \sqrt{\frac{64}{D^2}} = \frac{8}{D}$$

D = 8 inches distance.

The distance required to produce one skin unit is found by dividing the product of the three known factors by the standard formula for one skin unit $\frac{9}{16}$ instead of dividing the standard formula $\frac{9}{16}$ by the fraction with unknown distance as exemplified in obtaining the other factors.

The determination of distance and the number of skin units are both obtained by the same method.

From the foregoing calculations it is evident that the dose of unfiltered roentgen ray can be accurately and easily determined for both fractional and massive dosage. When all four factors are known, the product of their formula divided by the product of the standard formula for one skin unit, namely, $\frac{9}{16}$, will indicate the dosage in skin units. When, however, any one of the four factors is unknown and the other three decided on, the product of the standard formula for one skin unit, namely, $\frac{9}{16}$, divided by the product of the three known factors, indicates the unknown factor for one skin unit. When distance is the unknown factor, note the exception to this rule.

Owing to a proportionately large filtration of the ray generated below a 3 inch gap by the glass in the Coolidge tube, the above rule of unfiltered dosage does not apply.

This method of estimating roentgen ray dosage is also applicable in determining the number of plates that can be taken of a given case without the production of a permanent alopecia or roentgen ray burn.

For instance, how many plates or exposures can be made of a frontal sinus or anteroposterior diameter of the head without producing an epilation or erythema of the scalp? The formula or factors for such an exposure might be as follows:

Sp G	M A	D	T
5½	25	18 in.	10 sec.

This means that the plate is 18 inches from the target of the tube, and in this instance the scalp is 10 inches from the anode. In order to find the dosage which the scalp will receive, the formula must be changed from 18 inches to 10 inches.

Sp G M A D T
5½ 25 10 in. 10 sec. = ⅙ of a minute

$$\frac{5\frac{1}{2} \times 25 \times \frac{1}{6}}{10 \times 10} = \frac{27\frac{5}{12}}{100} = \frac{11}{48}$$

Take the standard formula for an erythema dose:

$$\frac{3 \times 3 \times 5}{8 \times 8} = \frac{45}{64}$$

Divide the erythema dose by the dose for each exposure:

$$\frac{45}{64} \div \frac{11}{48} = \frac{45}{\cancel{64}_{4}} \times \frac{\overset{3}{\cancel{48}}}{11} = \frac{135}{44} = 3\frac{3}{44} \text{ plates}$$

Thus three plates with these factors would not cause an erythema, but may produce a temporary alopecia.

By dividing the product of the factors of the standard formula for an erythema dose, namely, $\frac{45}{64}$, or one skin unit $\frac{9}{16}$, by an exposure formula, provided the skin distance is taken instead of plate distance, the roentgenologist can determine the number of plates he can make without producing an erythema or temporary epilation.

Four areas of a patient's back were treated with the following factors for each area:

(1) $\frac{3 \times 3 \times 5}{8 \times 8} = 1\frac{1}{4}$ skin unit

(2) $\frac{3 \times 6 \times 2\frac{1}{2}}{8 \times 8} = 1\frac{1}{4}$ skin unit

(3) $\frac{3 \times 4\frac{1}{2} \times 3\frac{1}{3}}{8 \times 8} = 1\frac{1}{4}$ skin unit

(4) $\frac{3 \times 9 \times 1\frac{2}{3}}{8 \times 8} = 1\frac{1}{4}$ skin unit

The photograph of the patient taken ten days after treatment demonstrates that all the areas coincide, yet in two of them, namely, (2) and (4), the spark gap or Sp G is doubled and one-half the time taken for exposure that was given in (1) and (3) respectively. It therefore follows that if the Sp G is doubled and the time reduced one-half, the same degree of erythema will be produced, other factors remaining constant.

From the standpoint of quality of the roentgen ray in the above experiment the formula with 6 Sp G should give a very large proportion of penetrating rays as compared with the 3 Sp G and 4½ Sp G. Hence one would expect that these penetrating rays derived from the higher Sp G would pass through the skin, and it would take much longer to produce the same erythema as was produced by the 3 Sp G and 4½ Sp G formulas which give a large proportion of rays of low penetration, and naturally would be absorbed in the outer layers of the skin and quickly produce a burn.

By actual experiment the reverse proves true. For it took just one-half the time to produce the same biologic effect in the doubled Sp G doses (6 Sp G and 9 Sp G) as it did in the 3 Sp G and 4½ Sp G formula.

It is, then, apparent that quality of the ray and absorption of the rays of long wave have little to do with the biologic effects in the skin. On the other hand, it seems that the factor which determines this effect is solely the quantity of roentgen ray reaching the skin, for it is obvious that a high Sp G produces more rays that reach the skin than the same dose with a low Sp G or spark gap.

We published the original communication establishing the principles and practical application of this method for both filtered and unfiltered dosage in the June issue of The American Journal of Roentgenology, 1917. Since the date of that publication Drs. MacKee [1] and Wise [2] have, in their respective papers, pointed out the efficacy of this method in the calculation of roentgen ray dosage in dermatology.

FILTERED *x*-RAY DOSAGE

The method of estimating filtered dosage differs from that of unfiltered in that each thickness of aluminum requires a separate standard or formula for one skin unit.

¼ mm. aluminum

$$\frac{9 \text{ in. gap } 5 \text{ MA} \times 42 \text{ sec.}}{10 \text{ in. dist.}} =$$

$$\frac{9 \times 5 \times \overset{42}{\cancel{60}}\ \overset{7}{10}}{\underset{2}{10}} = \frac{63}{10} = \frac{63}{20}$$

½ mm. aluminum

$$\frac{9 \times 5 \times 1 \text{ min. } 6 \text{ sec.}}{10} =$$

$$\frac{9 \times 5 \times \overset{66}{\cancel{60}}\ \overset{11}{10}}{\underset{2}{10}} = \frac{99}{10} = \frac{99}{20}$$

1 mm. aluminum

$$\frac{9 \times 5 \times 1 \text{ min. } 54 \text{ sec.}}{10} =$$

$$\frac{9 \times 5 \times \overset{114}{\cancel{60}}\ \overset{57}{30}}{\underset{2}{10}} = \frac{513}{30} = \frac{513}{60} = \frac{171}{20}$$

2 mm. aluminum

$$\frac{9 \times 5 \times 2 \text{ min. } 20 \text{ sec.}}{10} =$$

$$\frac{\overset{3}{9} \times 5 \times \overset{140}{\cancel{60}}\ \overset{7}{\cancel{3}}}{\underset{2}{\cancel{10}}} = \frac{21}{2}$$

3 mm. aluminum

$$\frac{9 \times 5 \times 2 \text{ min. } 34 \text{ sec.}}{10} =$$

$$\frac{\overset{3}{9} \times 5 \times \overset{154}{\cancel{60}}\ \overset{77}{\cancel{30}}\ 6\ 2}{10} = \frac{231}{2} = \frac{231}{10} = \frac{231}{20}$$

4 mm. aluminum

$$\frac{9 \times 5 \times 4 \text{ min.}}{10} = \frac{9 \times 5 \times \overset{2}{\cancel{4}}}{\underset{2}{\cancel{10}}} = 18$$

5 mm. aluminum

$$\frac{9 \times 5 \times 7 \text{ min.}}{10} = \frac{9 \times \overset{5}{\cancel{5}} \times 7}{\underset{2}{\cancel{10}}} = \frac{63}{2}$$

6 mm. aluminum

$$\frac{9 \times 5 \times 7 \text{ min.}}{10} = \frac{63}{2}$$

7 mm. aluminum

$$\frac{9 \times 5 \times 7 \text{ min.}}{10} = \frac{63}{2}$$

The time factor differs from unfiltered in its action on the skin and pastille with a 6 inch gap or less when the four factors are used that produce 1 skin unit and then a doubling of the time, other factors remaining constant, a reading of 1¼ skin units will be obtained. For each time that this process is repeated, the reading will advance one quarter of a skin unit.

A 7 inch gap gives 1½ skin units when double the time to produce 1 skin unit is used, and then begins to advance at the rate of one quarter of a skin unit for each exposure time thereafter.

The 8, 9 and 10 inch gaps, with three times the time exposure for one skin unit, gives two skin units, and then begins to advance at the rate of one-quarter skin unit for each exposure time. The only exception to this rule is when 5, 6 or 7 mm. aluminum are used, twice the time produces two skin units and then advances by half units to 3.

To illustrate the above, we will give below a list of readings made and reported by us in the original article.

Gap	MA	D	T	P
6	5	10	3 min. 51 sec. = 1	skin H
6	5	10	7 min. 42 sec. = 1¼	skin H
6	5	10	11 min. 33 sec. = 1½	skin H
6	5	10	15 min. 24 sec. = 1¾	skin H
6	5	10	19 min. 15 sec. = 2	skin H

Gap	MA	D	T	P
7	5	10	3 min. 18 sec. = 1	skin H
7	5	10	6 min. 36 sec. = 1½	skin H
7	5	10	9 min. 54 sec. = 1¾	skin H
7	5	10	13 min. 12 sec. = 2	skin H
7	5	10	16 min. 30 sec. = 2¼	skin H
7	5	10	19 min. 48 sec. = 2½	skin H
7	5	10	23 min. 6 sec. = 2¾	skin H
7	5	10	26 min. 28 sec. = 3	skin H

Gap	MA	D	T	P
8	5	10	2 min. 53 sec. = 1	skin H
8	5	10	5 min. 46 sec. = 1½	skin H
8	5	10	8 min. 39 sec. = 2	skin H
8	5	10	11 min. 32 sec = 2¼	skin H
8	5	10	14 min. 25 sec. = 2½	skin H
8	5	10	17 min. 18 sec. = 2¾	skin H
8	5	10	20 min. 11 sec. = 3	skin H

Gap	MA	D	T	P
9	5	10	2 min. 34 sec. = 1	skin H
9	5	10	5 min. 8 sec. = 1½	skin H
9	5	10	7 min. 42 sec. = 2	skin H
9	5	10	10 min. 16 sec. = 2¼	skin H
9	5	10	12 min. 50 sec. = 2½	skin H
9	5	10	15 min. 24 sec. = 2¾	skin H
9	5	10	17 min. 58 sec. = 3	skin H

Gap	MA	D	T	P
10	5	10	2 min. 19 sec. = 1	skin H
10	5	10	4 min. 38 sec. = 1½	skin H
10	5	10	6 min. 57 sec. = 2	skin H
10	5	10	9 min. 16 sec. = 2¼	skin H

Distance in filtered dosage, instead of obeying the law of light, produces double the effect at half distance instead of four times as in unfiltered ray. To substantiate this statement, the following factors were used with 3 mm. aluminum:

Sp. G	MA	D	T	P
9	5	6	7 min. 42 sec.	2½ skin units
9	5	12	15 min. 24 sec.	2½ skin units

A patient's wrists were placed beneath the tube, one at 6 inches distance from the target, the other at 12 inches, both wrists being exposed at the same time. The one at 6 inch distance was withdrawn at half time (7 min. 42 sec.) the other continued to full time exposure (15 min. 24 sec.) at 12 inch distance.

Ten days after the exposure, the erythema produced on each wrist was identical, thereby demonstrating that at full distance, doubling the time of half distance produces the same biological effect. This, then, establishes the fact that distance in filtered ray does not obey the same law as in unfiltered dosage. Hence the difference in the formula.

Unfiltered formula:

$$\frac{3 \times 3 \times \overset{2}{\cancel{4}}}{8 \times \underset{2}{\cancel{8}}} = \frac{9}{16} = 1 \text{ skin unit}$$

Filtered formula, with 4 mm. aluminum.

$$\frac{9 \times 5 \times \overset{2}{\cancel{4}}}{\underset{5}{\cancel{10}}} = 18 = 1 \text{ skin unit}$$

Pastille readings of filtered doses at full distance compared with biological and formulae determinations may be found in a recent article published in the *New York Medical Journal*.[4]

Spark gap and milliamperes in filtered dosage obey the same law as in unfiltered, namely, double the gap or double the M A equals double the dose.

The above experiment on patients' wrists has been duplicated on the backs of other patients by using two areas exposing one 7 minutes and 42 seconds and the other 15 minutes and 24 seconds with the other factors the same as a check on the findings reported on the wrists.

The employment of a formula to determine the amount of filtered dosage is not so simple as in unfiltered dosage, owing to the different thickness of the filter employed and the difference in the time factor, as pointed out above on 6, 7, 8, 9 and 10 inch gaps.

However, where aluminum is used as a filter, if one knows the factors that produce 1 skin unit with 3 mm. aluminum, it is not difficult to determine any dose where 3 mm. aluminum is used. For example, we know that 9 in. Sp G, 5 M A, 2 min. 34 sec., at 10 inch distance gives one skin unit with 3 mm. aluminum. How much time, with these as a standard, will it take to produce an erythema dose, namely 2½ skin units using 8 inch gap, 5 M A, at 10 inch distance with 3 mm. aluminum?

$$\frac{9 \times 5 \times 2 \text{ min. } 34 \text{ sec.}}{10} =$$

$$\frac{9 \times \overset{77}{\cancel{5}} \times \overset{154}{\cancel{10}}}{\underset{2}{\cancel{10}}} = 693 = 1 \text{ skin unit}$$

$$\frac{\overset{4}{\cancel{8}} \times 5 \times T}{\underset{2}{\cancel{10}}} = 4$$

$693 \div 4 = 173\frac{1}{4}$ sec. = 2 min. 53 sec. = 1 skin unit.

If it takes 154 seconds with a 9 inch gap to produce 1 skin unit, it will take as many seconds to produce 1 skin unit with an 8 inch gap as 4 is contained in 693, or $173\frac{1}{4}$ sec. = 2 min. 53 sec. In order to determine the time necessary for an erythema dose ($2\frac{1}{2}$ skin units) we must know that an 8 inch gap requires three times the exposure for 1 skin unit (2 min. 53 sec.) to produce two skin units, which is $3 \times$ (2 min. 53 sec.) = 8 min. 39 sec., and then it requires twice the time of one skin unit ($2 \times$ [2 min. 53 sec]) = 5 min. 46 sec. added to the time for two skin units to produce $2\frac{1}{2}$ skin units or an erythema dose. Thus 8 min. 39 sec. + 5 min. 46 sec. = 14 min. 25 sec., the time for $2\frac{1}{2}$ skin units using 8 inch gap, 5 M A, and 10 inch distance.

What is the dose when 4 mm. aluminum is used with 9 inch gap, 5 M A, 12 minutes time at 10 inch distance? The standard one skin unit with 4 mm. aluminum is $\frac{9 \times 5 \times 4}{10}$ = 1 skin unit. If it takes 4 minutes to produce 1 skin unit, it will take 12 minutes to produce 2 skin units, because it takes three times the time of 1 skin unit to produce 2 skin units with a 9 inch gap.

What would be the dose using 8 inch gap, 5 M A, 8 inch distance, and 10 minutes time with 3 mm. aluminum? The standard for 1 skin unit with 3 mm. aluminum is:

$$\frac{9 \times 5 \times 2 \text{ min. } 34 \text{ sec.}}{10} =$$

$$\frac{\overset{3}{\cancel{9}} \times 5 \times \overset{77}{\cancel{154}}}{10} = \frac{231}{10} = \frac{231}{20}$$

In order to determine the dose for the factors given $\left(\frac{8 \times 5 \times 10}{8}\right)$ we must first find the amount of time necessary to produce one skin unit with these factors.

Thus $\frac{8 \times 5 \times T}{8} = 5.$

the standard for one skin unit with 3 mm. aluminum ($\frac{231}{20}$) divided by 5 will give the time necessary.

$$\frac{231}{20} \times \frac{1}{5} = \frac{231}{100} = 2\frac{31}{100} \text{ min.} = 2 \text{ min. } 18 \text{ sec.}$$

If 2 minutes and 18 seconds is the time required for one skin unit, with 8 inch gap, 5 M A at 8 inch distance, it will take 4 minutes and 36 seconds to produce $1\frac{1}{2}$ skin units, and 6 minutes 57 seconds to produce 2 skin units, 9 minutes and 12 seconds to produce $2\frac{1}{4}$ skin units, with 48 seconds remaining. Ten minutes, then, would produce approximately a total of 2 1/3 skin units.

What would be the dose at 20 inch distance instead of 10 inch, with 4 mm. aluminum, 8 minutes time?

The standard for 1 skin unit with 4 mm. aluminum is

$$\frac{9 \times 5 \times \overset{2}{\cancel{4}}}{\underset{2}{\cancel{10}}} = 18.$$

The proposed factors are

$$\frac{9 \times 5 \times \overset{2}{\cancel{8}}}{\underset{4}{\cancel{20}}} = 18.$$

Therefore, to find the dose, divide by the standard formula, $18 \div 18 = 1$ skin unit.

Therefore, double time and double distance of the respective factors of one skin unit produces the same results with the formula as with the biological reaction.

It therefore becomes necessary in order to determine dosage of *x*-rays filtered through aluminum to know at least one complete set of factors as a standard that will produce 1 skin unit with a certain thickness of aluminum. Also to remember that a 6 inch gap or less begins quartering after 1 skin unit, 7 inches after $1\frac{1}{2}$ skin units, and 8, 9 and 10 inches after 2 skin units. Also that a 9 inch gap using 5, 6 or 7 mm. aluminum doubles the time of 1 skin unit = 2 skin units, and then increases at the rate of one-half skin unit.

In a recent sisue of the *New York Medical Record*[5] the relation of the erythema dose of unfiltered and filtered *x*-ray was found to be 1 to 2 according to Holzknecht scale, namely 1¼ skin units unfiltered = 2½ skin units filtered. Assuming that these formulae and the methods given here are correct from biological results obtained, it is quite evident that the effects produced both by the unfiltered and filtered ray are controlled by laws entirely different from those determining plate dosage or intensity of light.

We believe that these methods of determining dosage are practical, providing an original Coolidge *x*-ray tube with solid tungsten target and interruptless machine is used.

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THE EFFECT OF DIFFERENT FILTERS ON RADIUM RADIATIONS

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IN deep radium therapy filters of various metals are used to remove the beta and soft gamma radiation. There is considerable difference of opinion as to what metal is most suitable for this purpose. For instance, some use lead almost exclusively, and others condemn its use very strongly. In any case, what is of importance is the quality of the radiation reaching the tissue. A study of the absorption in tissue of the composite radiation from a source of radium or emanation, after filtration by different substances, is therefore of considerable importance. The experiments described in the following paper were made in order to ascertain the absorption curves for several metals which may be used as filters, and then to compare the penetration of the radiation in tissue after filtration through some of these metals.

Experimental Procedure.—The apparatus used is shown in diagram in Fig. 1. The gold leaf electroscope is connected to the central wire of the conical lead ionization chamber. This wire is kept at a potential of several hundred volts. The lower end of the ionization chamber is a very thin mica window. The source of radiation is a thin glass emanation tube, supported 12 centimeters below this window in a holder of mica and hard rubber. The various filters are placed directly over the emanation tube. The tissue is supported above the tube on a holder of hard rubber with a thin mica window, so that the filters can be inserted between the source of radiation and the tissue, without disturbing either. The electroscope is protected from direct radiation from the tube by the lead block.

The ionization current is measured by observing the time necessary to discharge the electroscope, the intensity of the radiation absorbed in the chamber being inversely proportional to the time, due correction being made for the natural fall of the leaf. Thus what is actually measured is the ionization produced in the air in the ionization chamber, and this depends on the amount of radiation absorbed. There are two factors which

might affect the quantitative accuracy of the readings. First, the lead ionization chamber gives rise to secondary radiation, which is different when the primary radiation consists largely of beta rays from that produced when the primary radiation is wholly gamma rays. Second, the air in the chamber absorbs different proportions of the beta and gamma radiation from the incident beam. These facts do not at all disturb the mutual relations of the curves obtained, or the validity of the conclusions drawn from them, for comparisons are to be made between different sets of filters giving the same ionization, and in any such case the proportion of beta and gamma radiation transmitted by one metal is not very different from that transmitted by another.

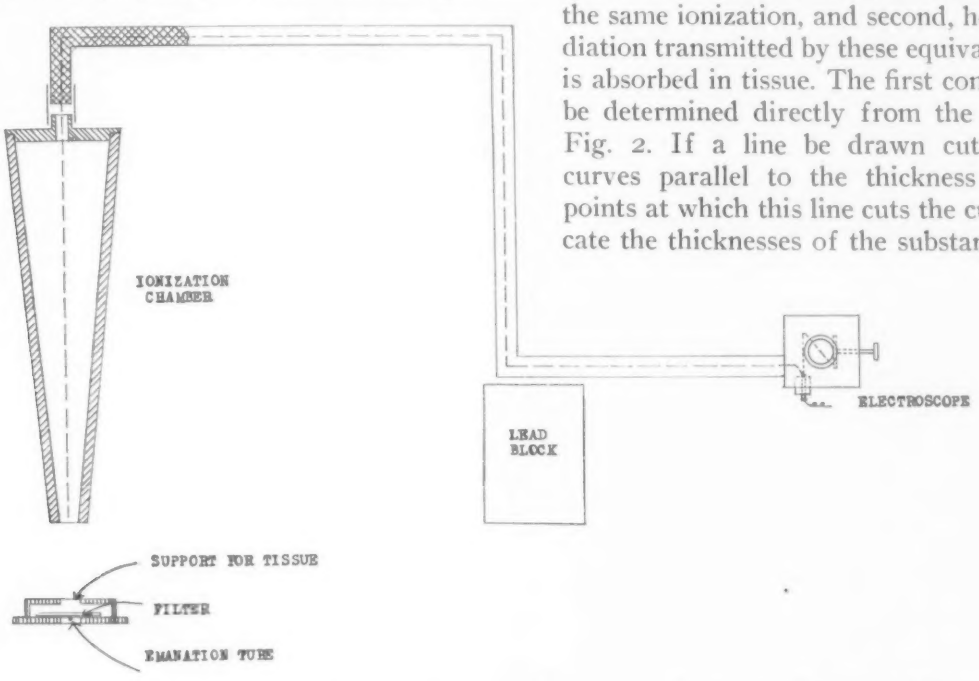

FIG. 1. APPARATUS USED FOR OBTAINING ABSORPTION CURVES FOR DIFFERENT METALS.

For each metal, the ionization current was measured first for the bare tube and then for increasing thicknesses of the filter. The reading for the bare tube was taken as 100 per cent, and the others tabulated in terms of this, allowance being made for the decay of the emanation during the experiment. The curves thus obtained are shown in Fig. 2, and the part of them showing the transition from the predominance of beta to that of gamma radiation is repeated to a larger scale in Fig. 3.

In order to compare the quality of the radiation transmitted through different filters, it is necessary first to determine the thicknesses of the different substances which give the same ionization, and second, how the radiation transmitted by these equivalent filters is absorbed in tissue. The first condition can be determined directly from the curves of Fig. 2. If a line be drawn cutting these curves parallel to the thickness axis, the points at which this line cuts the curves indicate the thicknesses of the substances which produce the same effect in the ionization chamber. For the test, aluminum, brass and lead were selected as being substances frequently used for filters, and covering a wide range of densities.

Six sets of filters were made in the manner just described. These were tested and modified slightly until the members of each set gave substantially the same ionization current. The thicknesses used were:

Aluminum	Brass	Lead
0.60 mm.	0.16 mm.	0.08 mm.
1.20	0.32	0.16
1.78	0.48	0.25
3.34	0.96	0.58
6.11	1.92	1.10
10.78	3.04	1.33

It will be observed that these thicknesses are

not proportional to the densities of the metals, the increase in absorption with the increase in atomic weight making necessary smaller thicknesses of the denser metals.

The tissue used was beef, hardened in formalin and cut very uniformly in thin slices by means of a meat slicing machine with a specially ground knife. Tests were made to find the difference in absorption by this formalin tissue and by fresh meat, and it was found that after the first few millimeters it was practically identical. Since the results embodied in this paper are qualitative rather than quantitative, the slightly higher absorption by fresh tissue in the first few millimeters is immaterial.

The question has often been raised by medical men as to whether dead and living tissue absorb the radiations to the same extent. Physical considerations lead to the conclusion that the absorption should be the same in both cases, as long as the amounts of the chemical elements present remain the same. Since the ultimate aim of this work was the comparison of doses given patients, it was thought desirable to make a direct experimental test of this matter. Two tests were made on the absorption of the same radiation by the same tissue when alive and dead. For the beta radiation, a rabbit was so placed that its ear was just over the emanation tube, and the ionization measured as previously described. The ear was then cut off, without removing it from its position, and the ionization measured soon after, and again one hour later. No difference in the absorption of the radiation by the tissue when it was a part of the live animal and when it was cut off was found. For the gamma radiation, a rat was used, the rays traversing its body. The ionization was measured while it was alive, soon after it had been given sufficient ether to kill it, and again twelve hours later. As before, no difference was observed. Therefore these results show that the absorption of radium rays is the same for dead and living tissue, within the limits of experimental error.

Measurements of the ionization currents were made for each filter with different thicknesses of tissue. The whole series of observations was repeated several times to determine definitely the relative positions of the curves. The results are given in Table 1, and the curves plotted from this data are shown in Fig. 4, those for the thicker filters being repeated to a larger scale in Fig. 5. In these curves the vertical distance from the axis of any point on the curve represents the intensity of ionization produced in the chamber by the radiation transmitted by the filter and tissue, and the horizontal distance indicates the thickness of tissue.

Discussion of Curves.—It is evident from these curves that the radiations after transmission through these "equivalent" filters of different substances, are not absorbed to the same extent in the tissues. Curve I of Fig. 4 shows the absorption by tissue alone. In Curves II, for the thinnest filters used, the curves start together and then diverge for a time, the lead being highest and the aluminum lowest. This, of course, means that for this set the radiation transmitted by the lead is the most penetrating. Groups III and IV are essentially the same, except that for a part of the way the lead and brass coincide. But in V, the brass and aluminum coincide for a part of the way and then the aluminum is above, while both are above the lead. In the last two groups the aluminum is highest and the lead lowest throughout, just the reverse of the first condition, and these curves do not come together again after traversing some thickness of tissue.

Since the radiation from the tube of emanation used is the same in all cases, and the ionization is the same when no tissue is interposed, the explanation of the phenomenon must be sought in the action of the filters on the radiation before it reaches the tissue. As previously explained, the equivalence of these filters is determined by the effect the transmitted radiation produces in the ionization chamber. However, the quality of the radiation producing the same ionization may be quite different. The curves show that differences do exist.

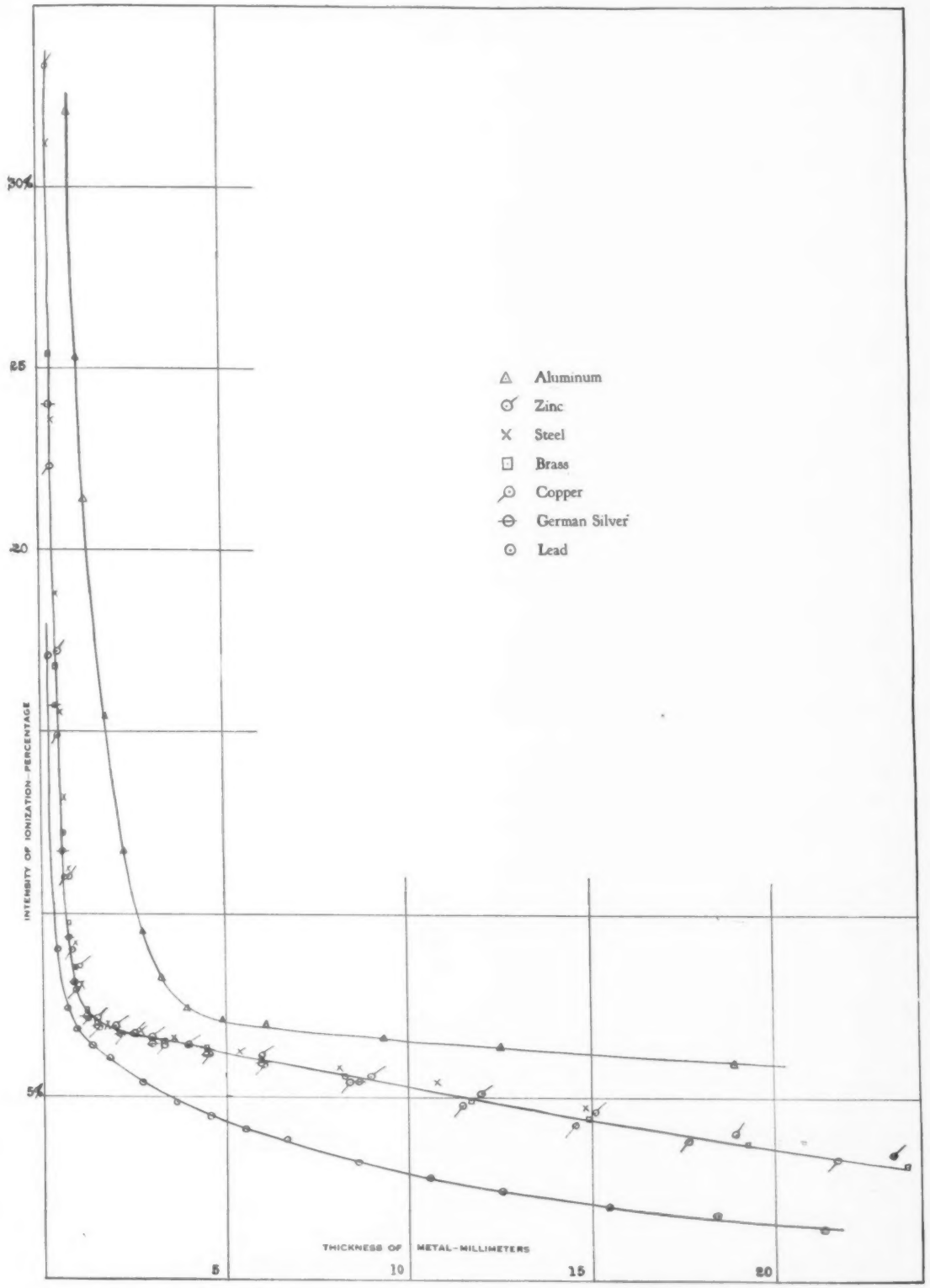

FIG. 2. CURVES SHOWING ABSORPTION OF RADIATION BY METALS.

There are three factors which are due to the filters and which may influence the shape of the curves: the true absorption of the primary radiation, the scattering of the primary radiation, and the emission of secondary radiation. These three phenomena occur whenever radiation traverses matter, and are determined by the nature of the substance traversed. They are all strictly atomic phenomena, that is, they are caused by the individual atoms, and not by the physical nature of the material. For instance, the density, or the packing of the atoms, has no influence on the absorption of the radiation per unit mass of the substance.[1] But the atomic weight, or the weight of the individual atom, is an important factor. For elements of very different atomic weights, the absorption, scattering, and secondary radiation are all different, even though account is taken of the difference in density. For instance, lead absorbs more of the beta radiation, mass per mass, than does aluminum. In other words, given a lead and an aluminum plate of equal area and equal weight, the aluminum being therefore thicker than the lead in the ratio of the densities of the metals, the lead will absorb several times as much beta radiation.[1] In the case of the gamma rays the effect is much less marked, the lead absorbing only a little more, mass per mass, than the aluminum.[2]

Besides the rays which are actually absorbed in the filter, others are scattered, and thus prevented from reaching the ionization chamber. For the beta radiation, a metal of high atomic weight scatters very much more than one of light atomic weight.[3] On the other hand, there is some evidence that for the gamma rays more scattering is produced by the light elements than by lead.[4]

Both the beta and gamma rays give rise to secondary radiation in the substance which they traverse. The secondary beta radiation thus produced varies in penetrating power with the atomic weight of the screen, that produced in lead being somewhat more penetrating than in the lighter elements.[5] The amount depends upon the thickness of the filter, increasing up to a certain point and then decreasing. The secondary gamma radiation increases rapidly in penetrating power and in amount with the atomic weight of the screen. However its amount is always only a small proportion of the primary beam, so that it is not an important factor.[6]

This absorption, scattering, and secondary radiation and their variations with the atomic weight of the elements (more properly the atomic number, which is the number representing the place of the element in the periodic table), are the factors from which the curves of Figs. 4 and 5 are to be explained. It is to be remembered that all three of these factors are acting simultaneously, and the total effect is due to their combined action.

It has been pointed out that in Curves II of Fig. 4 the radiation transmitted by the lead is evidently more penetrating than the others, for its curve shows a greater intensity of ionization for a given thickness of filter. This is what would be expected from the factors just discussed. The lead absorbs more of the beta radiation in proportion than the other substances, and the aluminum less. Also the lead scatters more of the beta radiation and the aluminum less. Both of these factors tend to make the radiation filtered through the lead consist of gamma radiation to a greater extent than that filtered through the aluminum, and therefore to be more penetrating. In addition, the secondary radiation emitted from the lead is more penetrating than that from the other metals.

Curves III are like II, except that all the radiation is now more penetrating, having passed through a greater thickness of filter. For the present the next three sets will not be considered. In the case of the last set there is a sufficient thickness of filter to cut out most of the beta radiation, so that the gamma radiation is now the controlling factor. The effects mentioned above, which tended to harden the beam from the lead, now become relatively unimportant. On the other hand, the scattering and absorption of the gamma rays are nearly the same for all substances, so that this factor is also of little consequence. There remains the secondary radiation. Lead emits a very copious second-

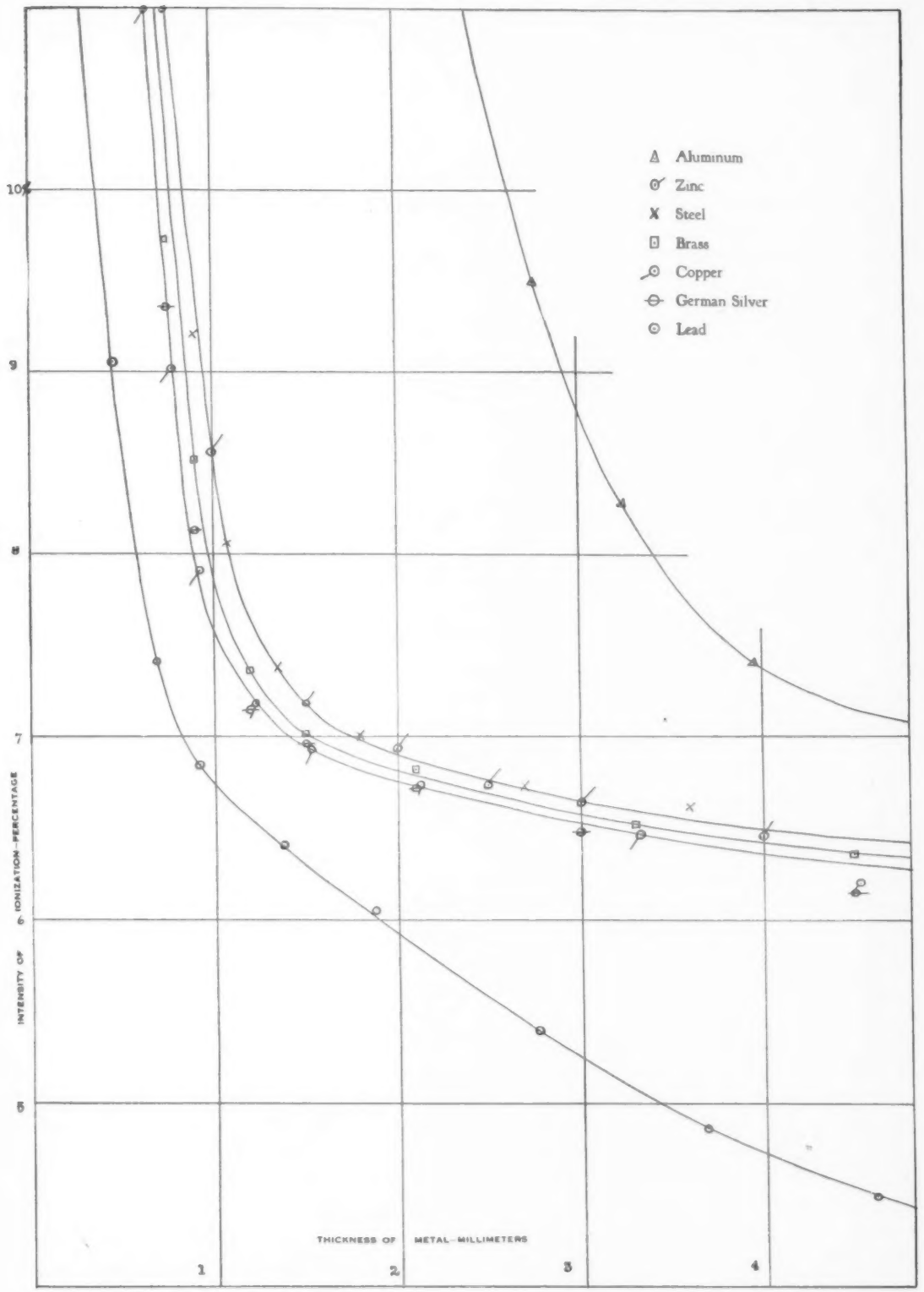

FIG. 3. CURVES SHOWING ABSORPTION OF RADIATION BY METALS.

ary radiation, much more than either of the other metals. Moreover, this thickness of lead is very nearly that found by Eve [5] to be that giving a maximum secondary radiation. On the other hand, aluminum reaches its maximum at 3 millimeters and then there is a decrease in the amount. This means that the beam from the lead filter contains much more secondary radiation than the others, and this, being softer than what remains of the primary beam, is much more readily absorbed in tissue. Therefore the absorption curve for lead in this group drops rapidly during the passage through the first centimeter of tissue.

Curves VI are of the same character as VII, and subject to the same interpretation. There remain the two intermediate groups. It is evident that in the operation of two effects, one tending to make the beam from the lead more penetrating than the others, and one tending to make it more absorbable, there must be some point at which it is the same as the others, and these two groups show this transition.

The first sets of curves, after being divergent for a time, come together again. In these cases the metal filters used are thin, and with increasing thickness the tissue becomes the predominant filter. This being the same in all cases, the effect is to make the transmitted radiation the same. On the other hand, in the last sets of curves the metal filters are thick and there was never enough tissue used to make it relatively important.

The first 5 millimeters of tissue absorb about 15 per cent of the radiation filtered through 1.33 millimeters of lead, while of that from 3.04 millimeters of brass—the equivalent as determined in this experiment—only half as much is absorbed. Even this is an appreciable amount, and when thick filters are used for deep therapy, measures are usually taken to remove the secondary radiation by an additional filter which will not in itself generate more objectionable rays. Sheet rubber is often used for this, so a test was made in which the tissue was replaced by rubber for certain filters. For those of the last three groups the absorption for the first centimeter was found to be practically identical with that for tissue. The points with arrows on the curve for 1.33 millimeters of lead indicate absorption by sheet rubber instead of tissue. From this it is evident that a thickness of a few millimeters of rubber is sufficient protection against secondary radiation.

The best filter for deep therapy is one that will give a penetrating beam with as little secondary radiation as possible. Brass gives less secondary radiation than lead, therefore in this respect it is a better filter. Brass is also one of the easiest metals to machine; it does not rust; it is hard, so that the applicators keep their shape; it is inexpensive and easily procured. Furthermore, 2 millimeters of brass is a sufficient thickness to remove the soft radiation. Since the curves for 1.96 and 3.04 millimeters of brass are practically parallel, the extra millimeter of brass has not increased the relative penetration appreciably, but it has absorbed 4 per cent more of the original penetrating radiation, thus decreasing the efficiency. This argument applies more strongly when 2 millimeters of lead are used as a filter, for in this case about 10 per cent of the penetrating radiation is absorbed.

Conclusions.—Equivalent filters of different metals have been determined, which give the same intensity of ionization in the apparatus described.

When the radiation filtered through these "equivalent" thicknesses is transmitted through tissue, the ionization produced is not the same.

For thin filters, up to half a millimeter of brass or its equivalent, the radiation transmitted by lead is more penetrating than that transmitted by brass, which in turn is more penetrating than that from aluminum. When the absorption by the tissue becomes great in comparison to that by the filter, this effect is obscured.

For thick filters, equivalent to one millimeter of brass, or more, this effect is reversed, the radiation transmitted by lead having a larger percentage of soft radiation than that transmitted by brass or aluminum.

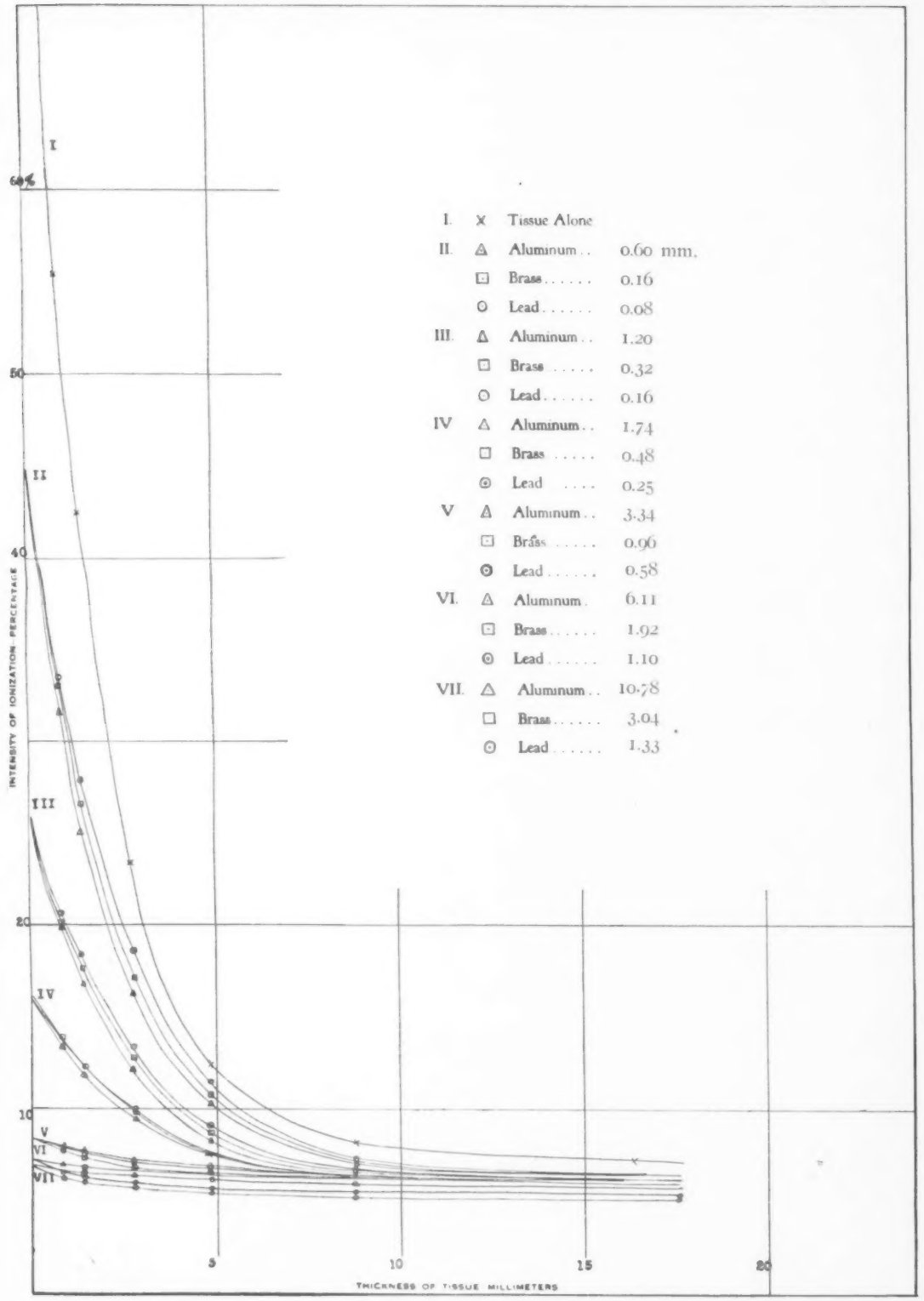

FIG. 4. CURVES SHOWING INTENSITY OF IONIZATION BY RADIATION FILTERED THROUGH METALS AND TISSUES.

To obtain the necessary penetrating radiation for deep therapy, in general a combination of filters is necessary. When substances of high atomic weight are used as filters, a considerable part of the emergent radiation is easily absorbed in tissue. Hence the necessity of a secondary filter of low atomic weight to remove this soft radiation. The analysis by tissue of the transmitted radiation enables us to determine what additional filtration is necessary when any metal is used as the primary filter.

For practical reasons brass is a good substance to use as a primary filter. Its secondary radiation is not very intense and can be removed to a sufficient extent by a few millimeters of rubber, which have the same effect as an equal thickness of tissue. A thickness of 2 millimeters of brass is sufficient for deep therapy.

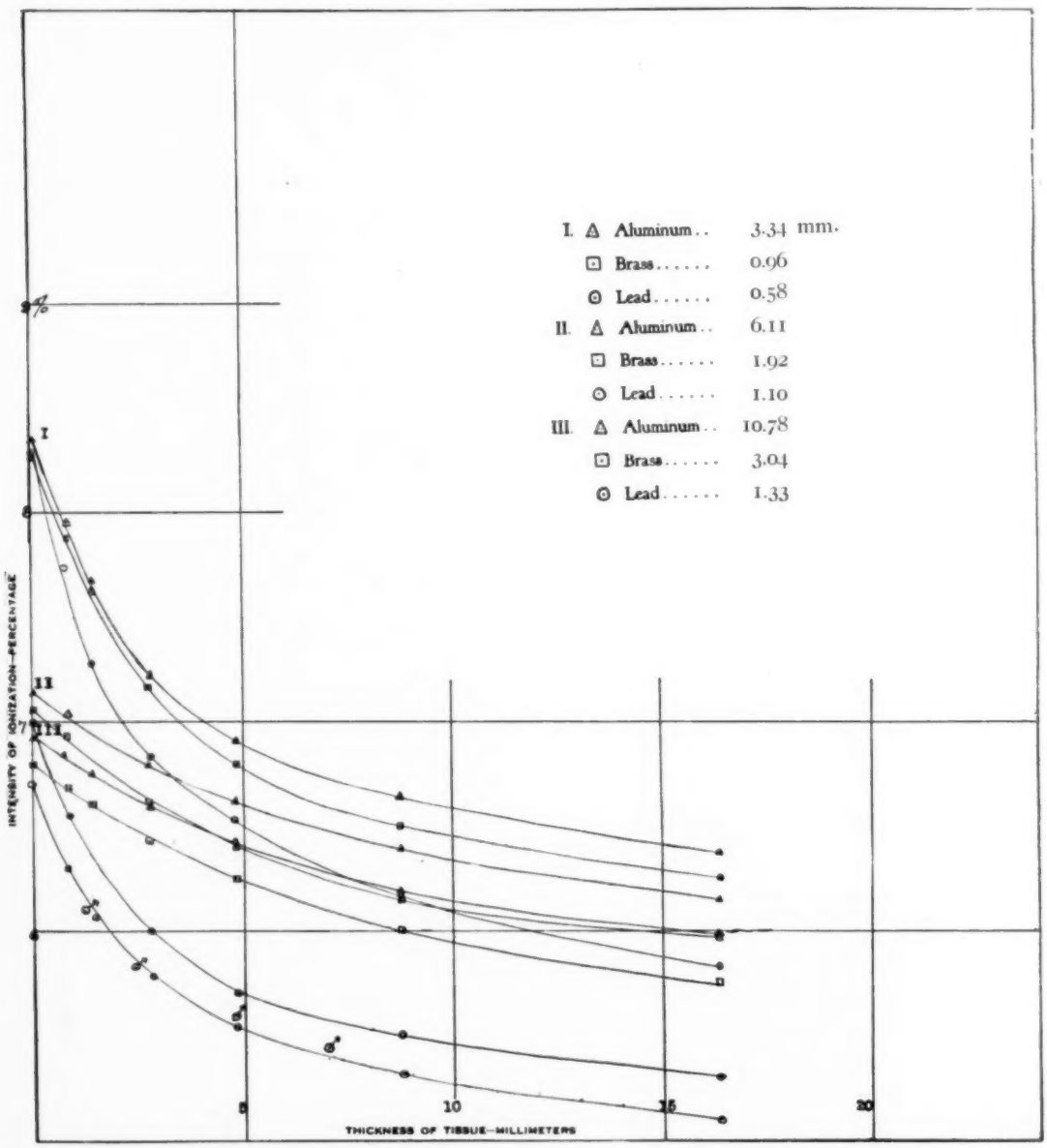

FIG. 5. CURVES SHOWING INTENSITY OF IONIZATION BY RADIATION FILTERED THROUGH METALS AND TISSUE.

The results obtained in these experiments are directly applicable to the treatment of patients, since the absorption by the tissue used is the same, within the limits of experimental error, as that by living tissue.

The writer wishes to express her thanks to Mr. Failla for suggesting this problem, and for his kind cooperation during the progress of the work.

TABLE I

PERCENTAGE OF IONIZATION PRODUCED BY RADIATION AFTER FILTRATION THROUGH METAL AND TISSUE

Filter	Millimeters of Tissue						
	0	0.82	1.40	2.77	4.84	8.74	16.35
Mica	100	55.4	42.5	23.5	12.4	8.24	7.18
0.60 mm Al.	44.8	31.6	25.1	16.3	10.3	7.04	6.55
0.16 Br.	44.8	33.0	26.6	17.1	10.8	7.10	6.55
0.08 Pb.	44.8	33.0	27.9	18.6	11.6	7.15	6.50
1.20 mm Al.	24.9	19.3	16.7	12.2	8.32	6.82	6.38
0.32 Br.	24.9	19.9	17.6	12.8	8.70	6.78	6.44
0.16 Pb.	24.9	20.2	18.4	13.4	9.10	6.80	6.32
1.74 mm Al.	15.9	13.4	11.8	9.51	7.50	6.70	6.38
0.48 Br.	16.1	13.9	12.3	9.92	7.69	6.64	6.26
0.25 Pb.	15.9	13.7	12.2	10.1	7.73	6.55	5.83
3.34 mm Al.	8.35	8.04	7.65	7.22	6.92	6.65	6.38
0.96 Br.	8.27	8.04	7.66	7.17	6.80	6.50	6.26
0.58 Pb.	8.27	7.76	7.28	6.83	6.56	6.18	5.83
6.11 mm Al.	7.14	7.06	6.94	6.81	6.64	6.40	6.15
1.92 Br.	7.06	6.94	6.82	6.61	6.40	6.15	5.98
1.10 Pb.	7.00	6.55	6.35	6.00	5.70	5.51	5.30
10.78 mm Al.	6.92	6.86	6.78	6.56	6.43	6.19	5.98
3.04 Br.	6.79	6.79	6.62	6.42	6.25	6.03	5.76
1.33 Pb.	6.70	6.30	6.03	5.78	5.54	5.32	5.10

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AN EXPERIMENTAL STUDY OF THE DURATION OF ARTIFICIAL PNEUMO-PERITONEUM*

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IN view of the extreme interest in the value of artificial pneumo-peritoneum for diagnostic purposes, it seems wise to settle a number of questions in regard to the procedure by means of experimental work on animals prior to making unlimited use of the procedure on human beings. Among the questions that have arisen are the following:

1. Minimum amount of gas.
2. Kind of gas.
3. Time that the gas remains in the peritoneal cavity.
4. Most suitable position in order to determine the nature of a particular lesion.

The following experiment was performed at the Edward N. Gibbs Memorial *X*-Ray Laboratory in conjunction with Prof. George B. Wallace, director of the Pharmacological Laboratory of New York University.

A male dog weighing 10 kilos was anesthetized by means of a solution of cholorotone in alcohol in the proportion of .4 gram chlorotone per kilo of body weight. The chlorotone was injected into the peritoneal cavity with a hypodermic syringe one hour prior to the injection of oxygen into the peritoneal cavity. The anesthetization was complete in twenty minutes. Complete anesthesia lasted for twenty-four hours. Oxygen was injected into the peritoneal cavity through a spinal puncture needle by means of displacement of water from one bottle to another. After 100 c.c. of oxygen had been injected a radiograph was taken in the postero-anterior position, prone. This showed good outlines of the abdominal viscera. Radiographs were then made after further injection up to 1,000 c.c., after which time the needle was withdrawn and a study made of the abdominal viscera in various positions of the body. (Fig. 1.)

Twenty-four hours later radiographs were made which showed an apparent diminution of oxygen in the peritoneal cavity. However, the information obtained was equal to that when the largest amount of oxygen was present.

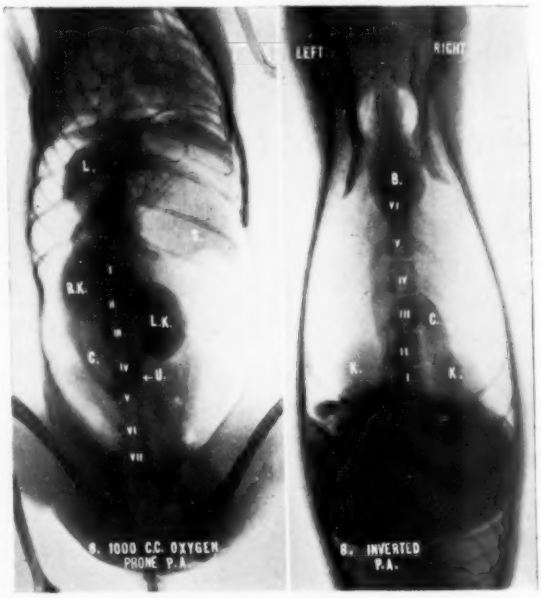

FIG. 1. PURE OXYGEN; IMMEDIATELY AFTER FULL INFLATION. *Left Hand Figure:* Taken prone with plate under abdomen. Note detail in all but pelvic region. *Right Hand Figure:* Taken with pelvis elevated to vertical position with plate anterior. This gives extreme definition to the pelvic organs. Note the bladder outline.

At the end of forty-eight hours radiographs were again made and were of equal diagnostic value. (Fig. 2.) An increase in size of the urinary bladder was very evident when compared with the original and twenty-four hour exposures.

*Read before the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., Jan. 31, 1920.

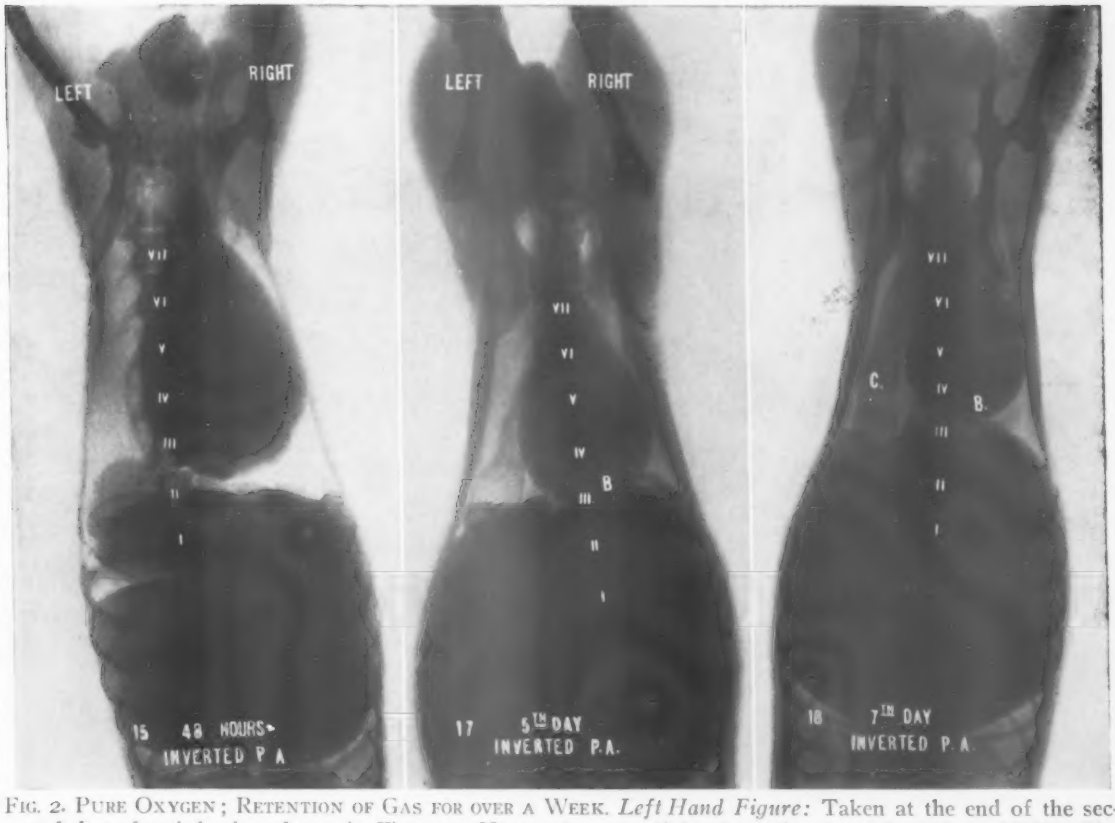

FIG. 2. PURE OXYGEN; RETENTION OF GAS FOR OVER A WEEK. *Left Hand Figure:* Taken at the end of the second day after injection shown in Figure 1. Note only *very slight* absorption has taken place. *Middle Figure:* Taken on the fifth day. *Right Hand Figure:* Taken on the seventh day, shows enough gas remaining to give diagnostic outline. In all three figures note the size of the bladder, indicating urinary retention and over-distention remaining even after the animal had recovered from the anesthetic.

On the third day exposures were again made which were of diagnostic value. They showed the bladder partly empty but retaining the effects of over-distention, as evidenced by its greatly elongated appearance. By this time the dog had recovered from the anesthesia.

Further exposures made on the 5th and 7th days were still of diagnostic value. (Fig. 2.)

On the twelfth day exposures showed that the gas had been so completely eliminated that the abdominal organs were not discernible.

CONCLUSIONS.

1. The presence of gas in the peritoneal cavity after the injection of oxygen can be demonstrated as late as eight days after the original injection.

2. A very moderate amount of gas is sufficient for diagnostic purposes. A proportion of about 2 c.c. of gas to 100 grams of body weight appears to answer this requirement.

3. The withdrawal of the gas appears advisable unless a rapidly absorbable gas, such as CO_2, is used.

4. The use of a more readily absorbable gas than oxygen appears desirable.

NOTE: Since this paper was read an effort has been made to follow the suggestion of Alvarez * and use carbon dioxide alone (Figs. 3 and 4) or a mixture of carbon dioxide and oxygen (Fig. 5). The results have demonstrated the very rapid absorption of carbon dioxide, and the retardation by means of mixing carbon dioxide and oxygen in suitable proportions.

* ALVAREZ, WALTER C. CO_2 Instead of O for Injecting the Peritoneal Cavity. *Calif. State J. M.*, Feb., 1920.

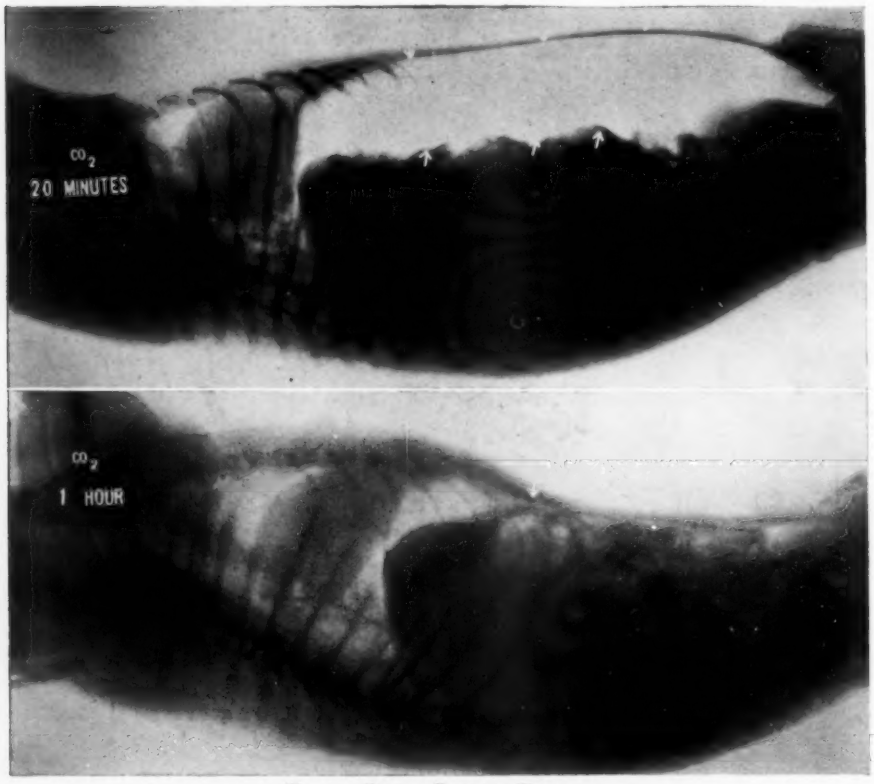

FIG. 3. PURE CARBON DIOXIDE.

Upper Figure: Taken in dorsal decubitus with the plate against the side. Note the abdominal contents have receded from the anterior abdominal wall, indicating the absence of any adhesions.

Lower Figure Taken Forty Minutes Later shows nearly all of the carbon dioxide has been absorbed. This offers a most striking contrast with the slow absorption noted in Figure 2 where oxygen was used.

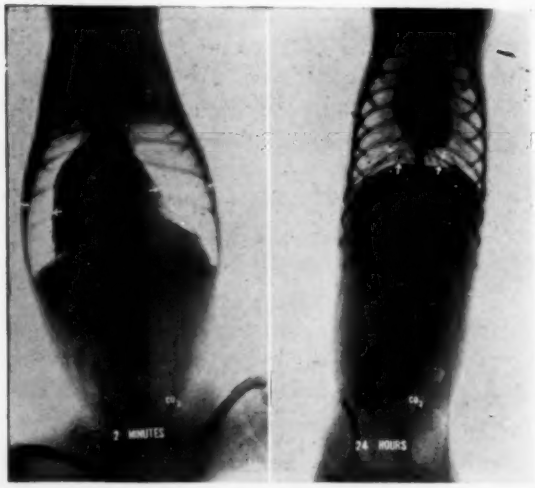

FIG. 4. PURE CARBON DIOXIDE, SHOWING FAINT TRACES OF GAS AT THE END OF TWENTY-FOUR HOURS (right hand figure). It is probable that this residual gas is not pure CO_2, but some other gases which have transfused during the absorption of the CO_2. Note, then, that in the case of CO_2, in spite of the fact that it is nearly all absorbed within the first hour, yet traces of this or some other gas can be detected as late as twenty-four hours.

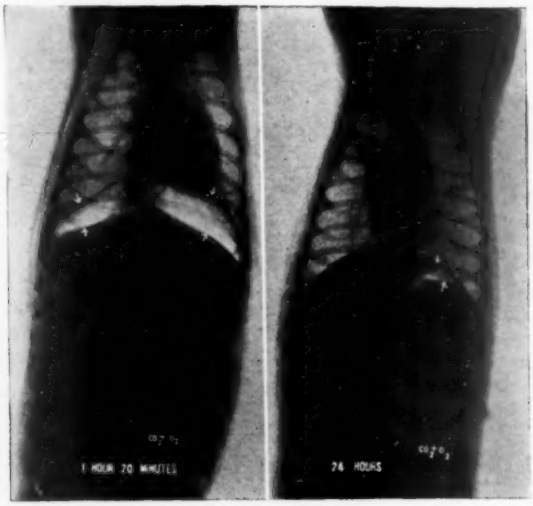

FIG. 5. MIXTURE OF CO_2 AND O. *Left Hand Figure* shows the retarding effect of oxygen on absorption. Compare with Figure 3, where absorption was almost complete at the end of one hour, while in this case a large amount of gas remains at the end of one hour and twenty minutes. Note in right hand figure a small amount of residual gas at the end of twenty-four hours.

THE VALUE OF THE ROENTGEN RAY IN THE STUDY OF DIVERTICULITIS OF THE COLON

THE RECOGNITION OF DIVERTICULITIS AS A CLINICAL ENTITY; CONSTIPATION AS AN ETIOLOGICAL FACTOR; PATHOLOGICAL CHANGES; SYMPTOMS; DIFFERENTIAL DIAGNOSIS; RADIOGRAPHIC CLASSIFICATION OF MULTIPLE DIVERTICULA; BIBLIOGRAPHY.

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[*Concluded from the September Issue*]

The various radiographic appearances of multiple diverticula roughly group themselves into three general classes. This radiographic classification corresponds with the grouping based on their pathology.

The *first class* is composed of cases showing simple diverticulum formation. The diverticula may be diffusely scattered throughout the colon. The patient may or may not have symptoms.

The *second group* consists of those cases showing beginning secondary inflammatory changes. These cases usually show the diverticula pretty well localized about the descending colon and sigmoid. The patients usually are having symptoms.

The *third group* consists of cases showing advanced secondary inflammatory changes, such as pericolitis, tumor, obstruction, etc. (Figs. 20-24).

GROUP I.—Occasionally in the course of the routine gastrointestinal examination, one will observe in the plate made twenty-four hours after the meal round discrete shadows of the same density as the barium-filled colon, but usually distinct from it. The shadows vary in size from that of a pinhead to a dime or larger. They are circular in outline and are in close proximity to the intestinal wall. Under the fluoroscopic screen they seem to be a part of or intimately connected with the wall, yet distinctly outside the lumen of the intestine.

These shadows represent the barium-filled diverticula. They may be seen anywhere throughout the entire colon from the cecum to the rectum. Any portion of the circumference of the gut may be affected. As these diverticula have a tendency to retain the barium, as mentioned before, the best time to observe them is thirty-six to forty-eight hours after the meal, at which time the lumen of the intestine is free of the barium and the round discrete shadows of the barium in the diverticula stand out clearly.

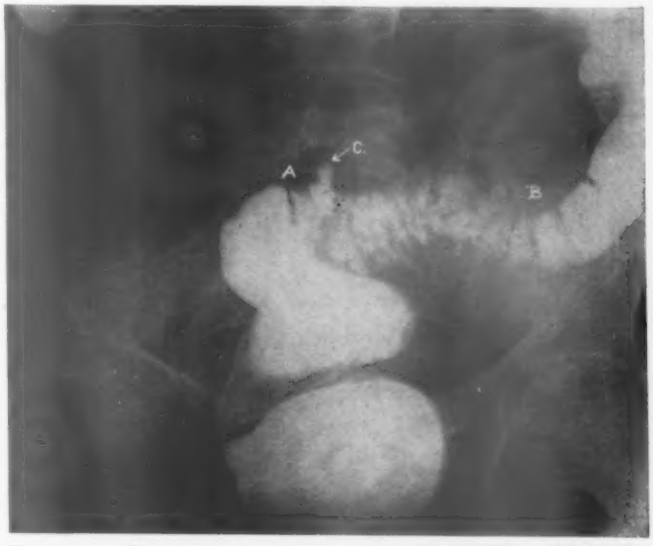

FIG. 20. DIVERTICULA WITH ADVANCED INFLAMMATORY CHANGES. Plates taken following the barium enema. Infiltration of intestinal wall from *A* to *B*. One large diverticulum at *C*. Symptoms of obstruction. Operation showed a chronic inflammatory mass. Class III.

These shadows, varying in number, may be seen anywhere along the course of the colon, the most likely site being the descend-

ing colon and sigmoid. In some of the extreme cases the diverticula appear very much like a string of beads.

The diverticula classified in this first group are frequently not associated with symptoms. They are occasionally found during a routine examination in people apparently well.

FIG. 21. A SMALL AREA OF INFLAMMATORY CHANGES OF THE BOWEL, at time of operation considered to be carcinoma. After study of microscopic section, it was decided not to be malignant and for that reason was placed in this classification.

As the condition is one of a simple diverticulum formation without inflammatory changes, about the only symptoms to be expected would be those of toxic absorption, the absorption being from the prolonged stasis of fecal material in the diverticula.

Two conditions may present radiographic pictures likely to be confused with simple diverticula. *First,* a hypertonic condition of the colon may be associated with almost a spastic condition of the haustra, so that discrete masses of barium become separated from the mass of barium in the lumen. The dependent portions of the haustra of the transverse colon seem to be a common location. The plates made at intervals will demonstrate that these apparent sacculations are only temporary. A true diverticulum is permanent. Again, study with the fluoroscope and barium enema will show that these haustral shadows are within the lumen of the gut and are not extramural, as is the case with the diverticulum.

Second, in a certain type of individuals the colon contents become subdivided into small discrete masses, particularly in the descending colon and sigmoid. A spastic type of constipation frequently produces this condition. These small masses may be confused with diverticula. The inconstancy of these shadows is the chief means of differentiation.

GROUP 2.—The second group in the classification of diverticulitis is composed of cases showing beginning secondary changes of an inflammatory nature. The diverticula in this group are usually localized along the lower descending colon and sigmoid. The patients invariably have more or less definite symptoms.

The *x*-ray plate shows numerous diverticula ranging from four or five to twenty, situated in a limited region about the junction

FIG. 22. MULTIPLE DIVERTICULA WITH CHRONIC INFLAMMATORY CHANGES. Plate taken after a barium enema. Narrowing of intestine from *A* to *B*. Operation showed tumor mass composed of chronic inflammatory tissue. Class III.

of the sigmoid and descending colon (Figs. 13-19).

The amount of intestine involved is not more than two or three inches. The important radiographic appearance differentiating this from the preceding group is a beginning narrowing of the lumen of the intestine. The apparent narrowing may at first be wholly due to spasm. It is usually best observed following the barium meal. Frequently the enema fails to reveal this spastic condition. In later cases, where there is actual thickening about the colon wall, the narrowing is constant both with the meal and enema.

Under the fluoroscopic screen there is usually found localized tenderness. The sigmoid may be fixed from inflammatory adhesions. The infiltration of chronic inflammatory tissue in and about the intestinal wall will produce a demonstrable rigidity of the wall.

FIG. 23. CHRONIC INFLAMMATORY CHANGES INVOLVING DESCENDING COLON AND SIGMOID. No diverticula are seen, but the intestine presents a serrated appearance such as is found associated with diverticulitis. Class III.

The condition which it is important to differentiate from cases in this group and the third group is *carcinoma*. I do not believe that a positive differentiation can always be made with the *x*-rays alone, particularly as a certain number of cases have malignant disease developing on top of a chronic diverticulitis. The history and physical examination as well as the laboratory findings are of the utmost importance in making this differentiation. In studying the *x*-ray plates there are one or two points which one must bear in mind when considering the possibility of cancer or diverticulitis.

FIG. 24. CHRONIC INFLAMMATORY CHANGES ABOUT THE DESCENDING COLON AND SIGMOID. Plate taken after a barium enema. The "serrated" appearance is more marked than in the previous illustration. The individual diverticula are not seen. Class III.

In the first place, the *x*-ray appearance of diverticulitis tends to remain constant even over long periods of time. If malignant disease is present, repeated examinations show a progressing lesion. If in a continued study of a diverticulitis case we find a portion of the involved area beginning to change its contour, one must be suspicious of a beginning malignancy.

Cancer, in general, is an intra-intestinal growth. The growth is in the wall of the colon, extending into the lumen and definitely circumscribed. The tumor mass in diverticulitis is outside the intestinal wall, being a pericolitis or perisigmoiditis. It is not definitely circumscribed.

FIG. 25. SAME CASE AS FIG. 24, SHOWING CONSTRICTION AT POINT *A*. Operation showed this to be chronic inflammatory tissue.

FIG. 26. CANCER OF THE COLON AT POINT *A*; *B*, TRANSVERSE COLON; *C*, HEPATIC FLEXURE; *D*, APPENDIX. Plate taken after barium enema. Note the abrupt transition from normal bowel to diseased bowel, which is characteristic of growth. In Figure 25 note that the transition from normal to diseased bowel is gradual. This is characteristic of chronic inflammation.

Hence when we find a filling defect in the colon producing a narrowing of the lumen, with the transition from normal bowel to diseased bowel, immediately we suspect cancer. With a narrowing due to diverticulitis several inches of colon on either side of the actual point of narrowing will show more or less evidence of disease. In other words, in diverticulitis the transition from normal bowel to diseased bowel is *gradual*, while in cancer the transition is abrupt (Figs. 20-26).

Obstruction from cancer is likely to be severe, rapidly progressive, and finally complete. Obstruction from chronic diverticulitis is usually not severe, with very gradual progress extending sometimes over a period of years, and rarely complete (Figs. 25 and 27).

Under the fluoroscopic screen an intermittent palpable tumor of the colon is always peridiverticulitis. A constant and persistent tumor mass may be cancer.

GROUP 3.—In the third group we put the cases showing advanced secondary changes associated with moderate to severe symptoms. In this group are the various forms of obstruction. The tendency in any chronic inflammatory mass is to contract. As we find a chronic obstruction following an indurated ulcer at the pylorus of the stomach, so with the inflammatory condition about the colon the same process takes place. The tendency in chronic diverticulitis is toward chronic obstruction, possibly extending over years.

The *x*-ray picture of colon obstruction is characteristic and needs no special comment. There is stasis proximal to the point of obstruction with possible dilatation of this portion of the intestine. This is studied best following the barium meal. Plates should be taken at sufficient intervals to determine the degree of obstruction—forty-eight or seventy-two hours after the meal, if necessary. The barium enema will confirm the meal and also give more detailed evidence as to the amount of colon involved and the degree of narrowing.

In this connection one must mention an

appearance of the colon which has become to our mind almost pathognomonic of chronic diverticulitis, although the diverticula themselves are not visualized. Particularly along the descending colon and sigmoid one occasionally finds a peculiar serrated appearance of the colon (Fig. 23). This may extend over several inches of the gut and is associated with more or less narrowing of the lumen. These serrations are small, close together, and with a rather sharp point, presenting at times a saw-tooth appearance. They will not be confused with haustral shadows, for they are too numerous and too small, and, more important, they are constant in shape and position.

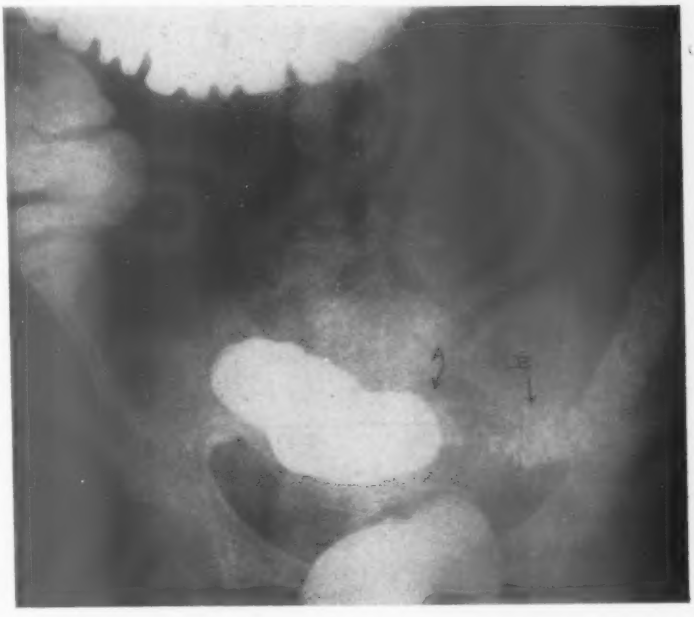

FIG. 27. CHRONIC OBSTRUCTION FROM DIVERTICULITIS. Lesion at points *A* and *B*.

This serrated appearance is best seen following the enema, although it may be observed in the twenty-four hour plate after the meal. Repeated enemata given on different days show this appearance to be constant.

The serrations do not change in size or shape. Furthermore, palpation under the fluoroscopic screen usually shows us that the intestine is more or less like a rigid tube. The walls are thickened and have lost their normal flexibility.

One infers that the serrated appearance is due to inflammatory thickening and induration in and about the intestinal wall, secondary to the presence of diverticula. The diverticula themselves not being visible, perhaps obliterated by the connective-tissue formation, are already so filled with mucus and fecal material that the barium is unable to enter.

There are other complications secondary to diverticulitis besides simple obstruction. Adhesions arising from the localized diverticulitis may involve other coils of intestines or other organs. Such a condition is best observed under the fluoroscopic screen.

Chronic perforation with abscess formation is not an uncommon sequel. The *x*-ray

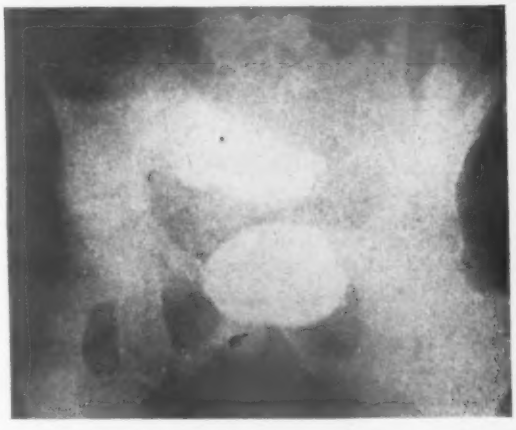

FIG. 28. SAME CASE AS FIGURE 27, four years later, showing complete obstruction to barium enema. Operation revealed chronic inflammatory mass.

appearance is no different from a chronic perforation of gastric or duodenal ulcer. The plate may show an abscess cavity filled with barium outside the lumen of the gut, with a small isthmus of barium connecting it with the intestine. Acute perforations do not come to the *x*-ray man.

Some of the acute diverticulitis attacks simulate a left-sided appendix. The barium enema may be of help in such cases by demonstrating that the cecum and appen-

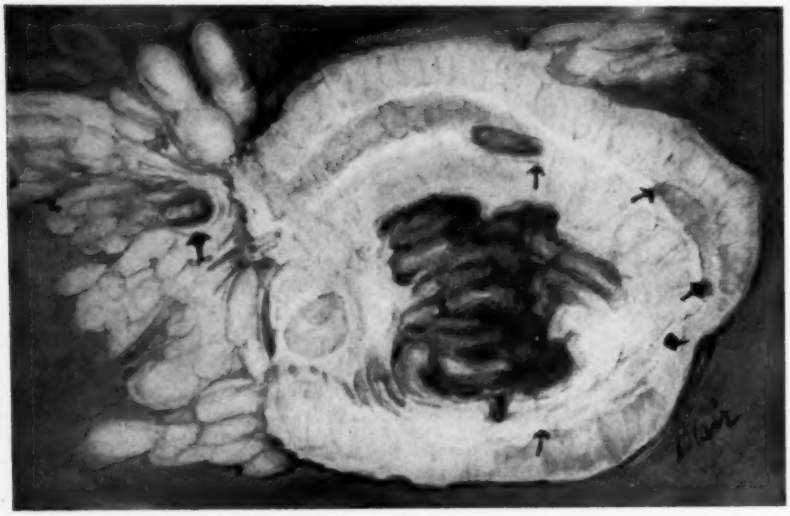

FIG. 29. DRAWING OF SPECIMEN TAKEN FROM THE PRECEDING CASE. Shows cross section of sigmoid, the wall of which is enormously thickened by chronic inflammatory tissue. Within the mass are seen the diverticula, to which the arrows are pointing. No evidence of malignancy.

FIG. 30. SHOWS MILD DEGREE OF DIVERTICULITIS, WITH SEVERAL DIVERTICULA.

dix are in normal position on the right side.

Rarely fistulae may result from diverticulitis. Several cases have been reported of fistulae connecting the bladder with the colon. Such conditions would be clearly shown on the *x*-ray plate.

In general, it must be borne in mind that the diagnosis of multiple diverticulitis is not to be made from the *x*-ray alone, although in some cases it may seem possible. The *x*-ray evidence must be considered in conjunction with the history, physical examination, and other laboratory findings. This is of particular importance in the differentiation of cancer and multiple diverticulitis.

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TWENTY-FIRST ANNUAL MEETING OF THE AMERICAN ROENTGEN RAY SOCIETY

THE AMERICAN ROENTGEN RAY SOCIETY'S Twenty-first Annual Meeting has passed into history as one which has sustained the traditions of the Society. That the scientific effort of the Society has advanced with that of general medicine is indicated by the papers, as well as by the scientific exhibit. The attendance was large, almost 700 having registered. The commercial exhibit was the largest and most diversified that we have ever had, including exhibits of radium as well as of every conceivable device of use to the radiologist. Some of the new apparatus showed much study, and is a decided improvement on the older standards.

The following program was carried out:

PROGRAM

MAYO CLINIC, ROCHESTER, MINN.

Tuesday Morning, September 14, 1920.

8 A. M. to 12 noon. Surgical Clinics.

St. Mary's Hospital:

Operating Room 1.—Dr. C. H. Mayo.
Operating Room 2.—Dr. W. J. Mayo.
Operating Room 3.—Drs. E. S. Judd and V. C. Hunt.
Operating Room 4.—Drs. D. C. Balfour and J. C. Masson.
Operating Room 5.—Drs. W. E. Sistrunk and C. A. Hedblom.
Operating Room 6.—Drs. J. D. Pemberton and A. W. Adson.

Colonial Hospital:

Orthopedic surgery.—Drs. M. S. Henderson and H. W. Meyerding.
Thoracic surgery.—Dr. C. A. Hedblom.

Worrell Hospital:

Oral surgery.—Dr. G. B. New.
Surgery of Ear, Nose and Throat.—Drs. H. I. Lillie and R. A. Barlow.
Dental surgery.—Drs. B. S. Bardner and L. T. Austin.

9 A. M. to 11 A. M.

St. Mary's Hospital:

Pathological demonstration.—Dr. William C. MacCarty.
Demonstration of Gross Pathology.—Dr. H. E. Robertson.

Radium Hospital:
Radium and Roentgen Therapy Clinic.
—Dr. H. H. Bowing.

Tuesday Afternoon at 2 P. M.

ADDRESS OF WELCOME: *The Relation of Roentgenology to Surgery;* by Dr. William J. Mayo.

Roentgenology in Bone Diseases: Dr. M. S. Henderson.

Pyeloroentgenography: Dr. W.F.Braasch.

Roentgenology in the Mayo Clinic: Dr. R. D. Carman.

A Comparison of Roentgenologic and Pathologic Findings in Gastro-Intestinal Lesions: Dr. W. C. MacCarty.

Radiumtherapy in the Mayo Clinic: Dr. H. H. Bowing.

Roentgenology in Dental Diseases: Dr. B. S. Gardner.

Graduate Education in Roentgenology: Dr. L. B. Wilson.

HOTEL CURTIS, MINNEAPOLIS, MINN.

Wednesday Morning, September 15, 9 A.M.

WELCOME: By the Local Committee; Dr. J. Frank Corbett, Minneapolis, Minn., Chairman.

RESPONSE: By Dr. James T. Case, Battle Creek, Mich., President.

Intra-Cranial Calcifications with a Case Report: Dr. John T. Murphy, Toledo, Ohio.

The Bucky Principle as Applied to Roentgenography of the Spine: Dr. Hollis E. Potter, Chicago, Illinois.

Studies on the Reduction of Bone Density: Dr. Dallas B. Phemister, Chicago, Illinois (by invitation).

A Retinometer, an Instrument for Measuring the Degree of Sensitiveness to Light of the Retina to be Used in Connection with Fluoroscopy: A. W. Pirie, Montreal, Quebec, Canada.

An Instrument for Comparing the Efficiency of Fluorescent Screens and the Fluoroscopic Vision of Individuals: Dr. David R. Bowen, Philadelphia, Pa.

An Attachment for Multiple Exposures with the Upright Fluoroscope: Dr. David R. Bowen, Philadelphia, Pa.

Leather-Bottle Stomach: Linitis Plastica: Dr. L. T. LeWald, New York City.

Wednesday Afternoon at 1:45 P. M.

Observations on the Behavior of the Normal Pyloric Sphincter in Man: Dr. C. W. McClure and Dr. Lawrence Reynolds, Boston, Mass. (By invitation.)

Roentgen Diagnosis in Diseases of the Heart: Dr. Gonzales Martinez of Paris, France, and Porto Rico. (By invitation.)

New Roentgenographic Technique for the Study of the Thyroid: Dr. George E. Pfahler, Philadelphia, Pa.

Roentgenographic Studies of Bronchiectasis and Lung Abscess After the Direct Injection of Bismuth Solution Through the Bronchoscope: Dr. H. L. Lynah and Dr. W. H. Stewart, New York City.

The Value of Lateral and Oblique Studies of the Chest: Dr. William A. Evans, Detroit, Mich.

Discussion, opened by Dr. Charles Lyman Green, St. Paul, Minn., and Dr. Percy Brown, Boston, Mass.

Thursday Morning at 8:30

Roentgen Ray Study of Dust Inhalation in the Granite Industry: Dr. D. C. Jarvis, Barre, Vermont. (By invitation.)

Lung Syphilis and Symbiotic Syphilitic-Tuberculous Lung Infection: Dr. W. W. Watkins, Phoenix, Ariz.

The Diagnosis of Primary Tumor of the Lung: Dr. Arthur C. Christie, Washington, D. C.

A Review of Chest Examinations in More Than Ten Thousand Cases: Dr. Kennon Dunham, Cincinnati, Ohio.

The Clinical Importance of the Different Types of Pulmonary Tuberculosis as Observed by Roentgen Examination: Dr. R. G. Allison, Minneapolis, Minn. (By invitation.)

Discussion of Papers, opened by Dr. Charles Lyman Greene, St. Paul, Minn.

Thursday Afternoon at 2:30

Lantern Slide Exhibit: One half hour.

THE CALDWELL LECTURE: *Peristalsis in Health and Disease:* Dr. Walter C. Alvarez, San Francisco, Calif., Assistant Professor of Research Medicine, George Williams Hooper Foundation for Medical Research, University of California Medical School. (By invitation.)

The Intralaryngeal Application of Radium for Papilloma: Dr. Preston M. Hickey, Detroit, Mich.

The Treatment of Carcinoma of the Breast by Imbedding Radium, Supplemented by X-Ray: Dr. Russell H. Boggs, Pittsburgh, Pa.

The Rationale of Radium-Therapy in Cancer: Dr. Isaac Levin, New York City. (By invitation.)

The Collateral Treatment of Malignant Patients Undergoing Radiotherapy: Dr. E. H. Skinner, Kansas City, Mo.

Cases Illustrating the Value of Prophylactic X-Ray Treatments: Dr. Samuel Stern, New York City.

Present Problems and Future Prospects of Deep Roentgen Therapy: Dr. Albert Soiland, Los Angeles, Calif.

Thursday Evening at 8:30

MOVING PICTURES

Technique of Examination of the Accessory Naval Sinuses and Mastoids: Dr. Frederick M. Law, New York City.

The Cancer Problem: Dr. J. M. Martin, Dallas, Texas.

Friday Morning at 9

Symposium—Technical.

Physical Investigation Work in Progress on Tubes and Accessories: Dr. W. D. Coolidge, Schenectady, N. Y.

The Influence of Scattered X-Rays in Roentgenography: Mr. R. B. Wilsey, Eastman Kodak Co., Rochester, N. Y. (By invitation.)

Practical Application of Mr. Wilsey's Results in General Roentgenology: Mr. Millard B. Hodgson, Eastman Kodak Co., Rochester, N. Y. (By invitation.)

On a Method of Making Quickly Roentgenographic Records of Screen Observations by Means of a Rotary Film-Holder: Dr. Percy Brown, Boston, Mass.

A New Device for the Protection of X-Ray Patients and Operators From Electric Shock from Any Part of the High Tension Circuit (with demonstration of same): Mr. Montford Morrison, Victor Electric Corporation, Chicago, Ill. (By invitation.)

Friday Afternoon at 2

Lantern Slide Exhibit: One half hour.

SYMPOSIUM ON ARTIFICIAL PNEUMOPERITONEUM

The Use of CO_2 in Producing Pneumoperitoneum: Dr. Walter C. Alvarez, San Francisco, Calif. (By invitation.)

Pneumoperitoneum as an Aid in the Differential Diagnosis of Disease of the Left Half of the Abdomen: Dr. A. F. Tyler, Omaha, Nebraska.

Pneumoperitoneum of the Pelvis (Preliminary Report): Dr. J. G. Van Zwaluwenburg and Dr. R. Peterson, Ann Arbor, Mich.

Diminutive Pneumoperitoneum (Intrauterine Oxygen Inflation Method) with Special Reference to Sterility and Allied Gynecological Conditions: Dr. I. C. Rubin, New York City. (By invitation.)

Discussion on the Symposium on Artificial Pneumoperitoneum, opened by Drs. Arthur Stein, New York, W. H. Stewart, New York, and L. R. Sante, St. Louis. (By invitation.)

An Unusual Case of Third Degree Burn (X-Ray) With Rapid Healing: Dr. Edward S. Blaine, Chicago, Ill.

Friday Evening

ADDRESSES MADE AT THE BANQUET

Toastmaster: Dr. A. W. Crane, Kalamazoo, Mich.

Special Address: *The Relation of Roent-*

genology to Clinical Medicine with Special Reference to Gastroenterology: Dr. R. Walter Mills, St. Louis, Mo. (By invitation.)

Remarks on European Trip: Dr. W. D. Coolidge, Schenectady, N. Y.

Remarks on European Trip: Dr. Walter C. Hill, Cleveland, Ohio.

A Historical Sketch of Roentgenology in Germany, 1914-1920: Dr. Leopold Jaches, New York City.

Forty-seven new names were added to the roll of active, corresponding and honorary members of the Society, as follows:

MEMBERSHIP

ALLISON, ROBERT G., M.D., Minneapolis, Minn.
BADER, ELLIS R., M. D., Cincinnati, Ohio.
BALLARD, CARL H., M.D., Omaha, Neb.
BERNSTEIN, BENJAMIN M., M.D., Brooklyn, N. Y.
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KANTOR, JOHN L., M.D., New York City.
KERN, M. F., M.D., St. Cloud, Minn.
KOENIG, EDWARD C., Buffalo, N. Y.
LAFFERTY, ROBERT H., M.D., Charlotte, N. C.
LAMB, R. F., M.D., Portland, Maine.
LAMBERT, JOHN H., M.D., Lowell, Mass.
LINDSEY, JOHN H., M.D., Fall River, Mass.
MACMILLAN, ALEX, M.D., Tufts College, Mass.
MARTIN, CHAS. L., M.D., Dallas, Texas.
MENVILLE, LEON J., M.D., New Orleans.
MERRILL, ADELBERT C., M.D., Boston.
MORRISON, L. B., M.D., Boston, Mass.
NICHOLAS, BERNARD H., M.D., Cleveland.
OSMOND, JOHN D., M.D., Cleveland, Ohio.
PANNETON, J. EUGENE, M.D., Montreal.
PAYNE, ROY A., M.D., Portland, Oregon.
PERKINS, CHARLES W., M.D., New York City.
PIERCE, HAROLD J., M.D., Terre Haute, Ind.
PILLSBURY, HENRY C., M.D., Washington.
QUICK, DOUGLAS, M.D., New York City.
REYNOLDS, LAWRENCE, M.D., Boston, Mass.
RICHARDS, CHARLES M., M.D., San Jose, Calif.
SANTE, L. R., M.D., Webster Groves, Mo.
SPANGLER, DAVIS, M.D., Sherman, Texas.
STEVENS, J. THOMPSON, M.D., Montclair, N. J.
SWANBERG, HAROLD, M.D., Quincy, Ill.
TOVELL, H. M., M.D., Toronto, Canada.
UPSON, W. C., M.D., Battle Creek, Mich.
WARD, CHARLES B., M.D., Spokane, Wash.
WHITE, FRANKLIN W., M.D., Boston.
WIDMAN, BERNARD P., M.D., Philadelphia.
WILLIAMS, JOHN G., M.D., Brooklyn, N. Y.
WOODALL, CHARLES W., M.D., Schenectady, N. Y.

HONORARY MEMBERSHIP

FORSELL, PROF. GOSTA, Stockholm, Sweden.

CORRESPONDING MEMBERSHIP

HEUSER, CARLO, M.D., Buenos Aires.
KAPLAN, ADOLOFO, M.D., Santiago, Chile.
MARTINEZ, GONZALEZ, M.D., Porto Rico.

The list of present officers of the Society will be found at the head of the Editorial Section of this issue of the JOURNAL.

NOTICE TO SOUTHERN ROENTGENOLOGISTS

The first meeting of the Section in Roentgenology of the Southern Medical Association will be held November 15, 1920, the first day of the regular meeting of the Association, at Louisville, Kentucky. Headquarters, Hotel Henry Watterson.

NOTICE OF SECOND ANNUAL MEETING EASTERN SECTION

The Second Annual Meeting of the Eastern Section of the American Roentgen Ray

Society will be held in Atlantic City at Haddon Hall-Chalfonte, on Friday evening and Saturday, January 28, 29, 1921. Make your hotel reservations early.

Communications regarding the program should be addressed to Dr. David R. Bowen, 82 West LaCrosse Ave., Lansdowne, Pa.

In all other matters concerning this meeting address Dr. Joseph M. Steiner, 103 Park Ave., New York City.

CORRESPONDENCE

24th September, 1920.

Secretary THE AMERICAN ROENTGEN RAY SOCIETY.

Dear Sir:

At the Thirtieth Annual Meeting, just held in Atlantic City, of the American Electrotherapeutic Society, the following officers were elected to serve for the ensuing year:

President

Byron Sprague Price, M.D.

Vice-Presidents

V. C. Kinney, M.D.
C. M. Sampson, M.D.
Charles Collins, M.D.
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E. C. Titus, M.D.
William Martin, M.D.
Frederic deKraft, M.D.

Secretary and Registrar

A. Bern Hirsh, M.D.

Treasurer

J. W. Travell, M.D.

If acceptable you may wish to insert the above into the news column of your Society's "JOURNAL."

Yours very truly,

A. B. HIRSH
Secretary and Registrar.

NOTICES

Notice has just been received of the death of Dr. Herschel Harris of Sydney, Australia. An obituary by Dr. L. J. Clendinnen will appear in a forthcoming issue of the JOURNAL.

TRANSLATIONS & ABSTRACTS

H. F. WILKINS, B.S., M.D., and WM. C. GEWIN, M.D. The Use of Radium in the Treatment of Metrorrhagia and Menorrhagia. (Paper read by title before the Chattahoochee Valley Medical & Surgical Association, at Columbus, Georgia, July 9, 1919, and subsequently published in *Radium.*)

1. In the discussion of these two conditions, it may not be out of place to mention some of the physiological effects of radium on cell life. All physiological or pathological effects of radio-active substance must be carried back to their action on protoplasm, whether it be the cells of plants or in the destruction of a neoplasm in the body, that is involved. A short exposure to radium accelerates the vital forces to a more energetic action of repair, while a more intense exposure inhibits them, which retardation may be cumulative and persistent through many generations of cell proliferation, hence the long time required to cure a radium burn.

2. There are various theories as to the specific effects of radio-active substances on cell life, and whether the radiation effects the enzymes of the cell is questionable. Suffice to say, that when we thoroughly understand the effects of radiation on biological cells, then we will be able to apply accurately radio-active therapeutics in the treatment of disease.

3. The treatment of uterine hemorrhage, with or without fibromyoma is so well established, that one must assume that a given dose will produce amennorrhoea. In women over thirty-five and under thirty, a temporary menopause can be brought about by a careful dosage, while in women over thirty the results will be less certain, and the number of cases of fibromyoma will shrink to insignificant proportions under proper dosage with radium.

4. Take for granted, then, that the above results are assurable, several problems are to be solved. The first of these, the proper selection of the cases for radiotherapy, and dosage concerns the general methods of applications and dosage of the radiation to obtain the results above mentioned. The conditions which are more often referred for this form of treatment are, first, those of excessive prolonged hemorrhage from the uterus with no gross pathological lesion, which occur at puberty, at the menopause, and to a less extent during the childbearing period, and secondly, fibromyoma of the uterus in all its phases of development. The cause of the bleeding in the grossly normal uterus up to ten years ago was thought to lie in the anatomical lesions, which indicate various stages of inflammation either in the endometrium or in the muscles. Chronic endomotritis was applied to all conditions of the endometrium, in most cases of uterine hemorrhage. This idea as to the cause of uterine bleeding has been discredited by the more recent investigators where records have already been shown that the swollen congested edematous membrane is the counterpart or exaggeration of the intermenstral endometrium, and that it is concerned, no doubt, in the actual bleeding from the uterus, which, nevertheless, shows evidence of being stimulated by the same influence such as substances, which bring on menstruation. The latest researches show that such substances do exist in the corpus luteum, and in the placenta, and that in individuals suffering from uterine hemorrhage there is found a ripe corpus luteum, and in normal menstruation the cycle of hypoplasia and depletion through which the endometrium passes, is coincident with the cycle of development, and recession of the corpus luteum, and that the bleeding is dependent upon the corpus luteum is now absolutely believed. It is almost certain that the pathological, as well as the normal uterine bleeding, is due to some disturbance of the Graafian follicle in some stage of its development, whether this is effected by other granular substances, etc., or not. The pathological hemorrhage is a variation in amount, duration, character and periodicity from the normal menstrual flow.

5. If the abnormal uterine bleeding is nothing but a variation of the normal, and we wish to produce its cessation, the logical procedure is to destroy the essential element in the menstrual cycle, i.e., Graafian follicle. Next to the lymphocyte and the spermatozoa, the ripe Graafian follicle is most susceptible to the action of radium. It needs but a step to apply these agents to the Graafian follicle to bring about the condition of the normal or pathological uterine flow. The ripe follicle is much more

susceptible than is the primordial follicle, and if the dose of radium be regulated to destroy only the follicles of an advanced degree of development, then a definite period of amenorrhea can be brought about, depending on the number of primordial or immature follicles remaining after the exposure to radium.

6. Uterine hemorrhage is often accompanied by gross anatomical lesions in the uterus, and a complete analysis concerning such cases shows that in four conditions does there appear to be any association between the bleeding and the pathological conditions and changes. The conditions which cause hemorrhage from the uterus are (a) a small percentage of cases of hemorrhage due to pelvic inflammation, (b) a large percentage due to retro-version, although the displacement may be complicated with cystic ovary, infantile uterus, etc., (c) the third group includes the ulcer-active conditions, such as carcinoma, polypus, pedunculated submucous fibroids, (d) the fourth cause of uterine hemorrhage is fibromyoma of the uterus. There is no doubt as to the definite coincidence of these conditions, however, the casual relationship is still obscure, that menorrhagia may be coincident with fibroid without any casual relationship and that the bleeding may recur after the fibroid has disappeared, without a recurrence of the fibroid can be easily substantiated by many cases.

7. An interesting question which arises from a study of these cases is what relation they may have to the uterine hemorrhage when the bleeding reappears in the absence of the tumor, but one can not refrain from feeling that there is a coincidence in the presence of a fibroid and a functional menorrhagia. A close study of these cases will show that there are some casual relationships between many fibroids and the uterine bleeding, and one is almost forced to conclude that all fibroids exercise a contributary, if not an essential role in many cases of bleeding from the uterus, because in no case of fibromyoma treated by radiotherapy, that has been reported, has there been any more trouble experienced than has been encountered in the treatment of the grossly normal uterus. The excessive hemorrhage in this class of cases is due to a disturbance in the proper relationship between the elemnts which control menstruation, and hence the ideal treatment is to restore that relationship. In the hemorrhage in young women, the disturbance is one of development, and every effort should be made to restore this balance by general treatment, which is to replace deficient factors by curettage, if necessary, even though improvements follow only in about 10 per cent of the cases so treated. It has been found that the treatment by radium is far better in all these cases. In women over thirty partial amenorrhea can be promised with somewhat greater difficulty, but in most instances, certainly. In this class the promise of a permanent menopause, rather than to any radiotherapeusis that may have been used.

8. Six hundred and twenty-five milligram hours intra-uterine, with 0.5 millimeter filter is safe in a woman under thirty-five. Over that the dosage is better cut down by a millimeter of brass. In women around thirty-eight or over, radiotherapy becomes the method of choice, because the menstrual balance is disturbed by the approach of old age and the cessation of the child bearing period, probably due to the decadence of the ovarion function. Since the natural menopause is imminent, it would seem to be logical to precipitate it and try to save the woman months or even years of partial or complete incapacity from uterine hemorrhage. In such cases massive dosages are indicated from the starting of the radiotherapeusis.

9. The treatment of bleeding associated with retroversion is very much like the above. The most prominent symptom, the displacement, should be corrected in all cases, if possible, without operation, and the effect upon the bleeding noted. In younger women an operation should be performed if reduction of the displaced uterus fails. In older women having the symptoms from the retroversion, it seems fairer to leave the displacement alone, because the reduction in older women has not, in our experience, relieved the bleeding. In these women radiotheraphy should be resorted to at the beginning of the hemorrhage.

10. The excessive hemorrhage associated with fibromyoma of the uterus can not be treated alone, but must be considered along with the whole question of the proper treatment of fibromyoma. Before the use of radium there were certain principles governing the treatment of fibrosis. The first of these was that the fibroid itself was a menace and caused no damage except by its size, and that would not change from a benign tumor to a sarcoma.

Secondly, that such a zbroid should not be treated unless it gave symptoms, because sarcoma is so rare that operating on mere superstition would harm more individuals than it would help. The symptoms for which operation was advised were, in the first place excessive hemorrhage, secondly, variations due to pressure on nerves or organs, and thirdly, rapid growth or large size of benign tumor mass.

11. With radium as a curative agent the problem as to the best method of treatment remains the same, i.e., the new problem of the proper class of cases needing treatment of the fibromyoma which are suitable for radio-active treatment, and of those cases which should be operated on. As above stated, the results to be expected from radiation are, first, the cessation of bleeding; second, the shrinking of the fibromyoma. This shrinkage requires varying lengths of time in different cases, and should receive scant consideration from the radiotherapeutist. If a mass is pressing on any important organ, or if the tumor is extremely large, and if the patient's health permits operative risk, the mechanical removal of the tumor seems to be better treatment under our present status of information, however, any excessive hemorrhage in these cases should receive treatment by radium in all cases in which a menopause is acceptable, but in younger women this method of treatment is not indicated unless the general condition of the patient would not permit of surgical interference. Because in the younger class if radium is used it should be applied in massive doses, in which we expect only a complete cessation of the ability to bear children. A menopause is almost sure to result if any good is obtained from this treatment. Then if we temporize with small doses of radiotherapy, the chances are that a sarcomatous condition would result, and more energetic application of the radium would have to be used if results are to be expected.

W. W. Belden.

De Niord, Hollis H., M.D., and Richard N., M.D., and Schreiner, Bernard F., M.D., Buffalo. The Effect of Roentgen Rays on the Metabolism of Cancer Patients. (*Arch. of Int. Med.*, Vol. 25, No. 1, January 15, 1920.)

The ever increasing scope of blood chemistry studies has enabled the authors to estimate quantitatively factors representing protein, fat, carbohydrate and salt metabolism and storage. Everyone is familiar with the cachexia of cancer sufferers, and the early stage at which it sometimes appears, making it practically a diagnostic symptom of malignancy. With this in mind, their efforts have been directed toward the actual cause of the loss of weight, whether due to (1) deficient food intake; (2) absorption of toxins from secondary infection of the tumor, or (3) to some specific action of cancer cells that prevents storage and utilization of foodstuffs. Following radium and roentgen-ray treatments, many patients show marked improvement or are cured, and the question arises whether the roentgen ray produces any discernible change in the blood chemistry and how long such a change must exist to effect a general improved metabolism, and whether the effect of the roentgen ray is a general one or only a local destructive action on tumor cells. They, therefore, chose ten readily estimable factors for the study of the blood chemistry, and the complete studies were made immediately before roentgen ray exposure, one half an hour after, and on the next day, approximately twenty-four hours afterward. The entire study is preliminary to, and in the nature of a report of, the broader observations with which they are now engaged. The following were estimated in mg. per 100 c.c. of blood in each instance: 1. Urea. 2. Creatinin. 3. Uric acid. 4. Chlorids. 5. Cholesterol. 6. Fatty acids. 7. Total fats. 8. Sugar. 9. Diastatic activity. 10. Plasma and corpuscle percentage. The cases selected for study were not taken at random as only those patients were selected who were practically free from renal disease, in order to obviate the matter of retentions. Several control studies were made on normal people subjected to the same roentgen ray exposure. With another control group of cancer patients, they took 60 c.c. of blood at the same interval as in the roentgen ray studies but without roentgen ray exposure.

Their object in this paper has been to note the effect of roentgen rays on cancer patients, as manifested by changes in their blood chemistry, and to continue investigation of the individual blood factors where it seemed to be indicated. 1. Urea, urea nitrogen and creatinin showing nothing characteristic of the cancer

patient. 2. The moderate uric acidemia which exists for a short period of time after exposure to roentgen rays is the result of nuclear degeneration but is not especially characteristic of malignancy. 3. The sodium chlorid content of cancer patients is altered neither by the presence of the tumor nor the exposure to roentgen rays. 4. The cholesterol, fatty acids and total fats are generally increased in the blood, but this is not in proportion to the duration of exposure to the roentgen ray or varied as to the type of tumor. The increase of cholesterol in the blood is probably due to cellular autolysis with liberation of cholesterol, induced by the action of the roentgen rays. Fatty acids and total fats are consistently high in the blood of cancer patients and this increase is reduced by the roentgen rays. They do not care to give any reason or hypothesis for the reduction, as they are at present carrying on further studies along this line.

5. There is nothing in the behavior of the blood sugar or diastatic activity that is diagnostic of cancer. They have noted, however, that the roentgen rays activate the diastase for a short period of time to a greater than normal activity. 6. The plasma and corpuscle percentages were unaltered by the effect of the rays, and were of no diagnostic value in cancer.

W. W. BELDEN.

WISE, FRED, M.D. Roentgen-Ray Treatment of Widespread and Generalized Diseases of the Skin. (*J. Am. M. Assn.*, Vol. 73, No. 20, p. 1491.)

In the early days of the roentgen ray, it was used empirically in the following:

"For example, such affections as epithelioma and sarcoma, the various granulomas, keloid, ringworm of the hairy surfaces, and other diseases which did not readily respond to the older methods of treatment in common use at the time, would be, so to speak, consigned to the mercies of the roentgen ray, to reap the benefits of, or to suffer the evils from a subtle and powerful therapeutic agent, the precise nature and action of which is to this day unknown. Even in such relatively small and well defined lesions as basal cell epitheliomas, keloids, warts and circumscribed granulomas, the administration of the roentgen ray was at one time, not far gone, a more or less haphazard, indeterminate process, the outcome of which, if it resulted favorably, was often at best only 'the happy combination of fortuitous circumstances.'"

EXACTNESS IN THE ADMINISTRATION OF DOSAGE OF RAYS

"As is well known, the last few years have witnessed great strides in the science and art of roentgenotherapy as applied to cutaneous affections. Improvements in the manufacture of the various types of exciting apparatus, and in devices for measuring the quality and quantity of the rays, have done much toward the introduction of many refinements in technic, so that we are enabled today to measure the exact quality and to determine the exact quantity of a given roentgen-ray emanation, without the least difficulty; in other words, we can easily administer an exact dosage of roentgen rays. These improvements in apparatus and advances in technic have culminated in the production of the Coolidge tube with its remarkable flexibility and its steady delivery of rays of uniform quality.

"The present-day degree of perfection attained in this method of treatment of skin diseases may therefore be measured by the facility and the simplicity with which a given dose may be safely and accurately administered, within a specified and reasonable length of time. This degree of perfection was not arrived at without much laborious experimentation and investigation; and the modern dermatologist owes a large debt of gratitude to such diligent workers and scientists as Sabouraud and Noire, Benoist, Holzknecht, Kienbock, Pusey and Caldwell, MacKee and Remer, Witherbee, Shearer, Corbett, Hampson and many others."

The technic which is now employed is that which is used in the Vanderbilt Clinic under the direction of Dr. John Remer. This technic was elaborated and standardized by Drs. McKee and Remer. It does not depend upon the various titles radiometer or similar devices but the dose is regulated by the spark-gap backup and the quantity of current going through the tube and the length of time of exposure.

"To obtain one Holzknecht unit at 'skin distance,' that is, with the exposed pastil of barium platinocyanid resting on the skin, the

following factors were found to be serviceable as convenient working constants: length of parallel spark gap, 6 inches; amount of current passing through the tube, 2 milliamperes; distance from the anode to the skin, 8 inches; time of exposure, three minutes.

"With the Coolidge tube backing up a 6-inch parallel spark gap, the Benoist penetrometer reading is approximately No. 8, that is, a 'hard' ray. Experience has taught that a No. 8 to 9 B ray is to be preferred in dermatologic practice, to much softer or much harder amanations."

W. W. BELDEN.

LANGMEAD: Notes of a Case of Esophagectasis in an Infant, with Radiograms. (*Proc. Roy. Soc. Med.* Vol. XIII, No. 5, March, 1920.)

Patient was a baby girl, aged fifteen months, who vomited after nearly every feeding. Family history unimportant; child born at term, normal labor. History of vomiting, not projectile, about one hour after feeding. Vomitus was unaltered milk. Physical examination revealed an emaciated child with lively knee jerks. Urine contained acetone.

Fluoroscopy after a bismuth meal revealed a dilatation of the lower esophagus, about the size of a hen's egg. A small amount of food entered the stomach. The esophageal condition was the only defect observed, and was believed to be due to congenital want of relaxations of the cardiac sphincter. No operation was deemed advisable. Attempts to pass a tube without anesthesia were uniformly unsuccessful. The child left the hospital unrelieved. It would be of interest to know the final outcome of this case.

L. S. GOIN.

PICKEREL. Extensive Lesions of Anthracosis and Pneumoconiosis with Absolute Absence of Physical Signs. (*J. de radiol. et d'électrol.* 1920, Vol. 4, p. 34.)

To distinguish pneumoconiosis from certain forms of pulmonary tuberculosis is often difficult in radiology. In the case cited the radiological features offered such a contrast with the stethoscopic signs which were entirely lacking. M. M., a joiner, having suffered for two years with enteritis and abdominal pains, came to examination for a suspected hepatic lesion. To the surprise of all concerned, when the thorax was thrown upon the screen unexpected lesions were found. The edges of the lungs were full of dark spots and opaque granulations extended over both lungs, the more luminous standing out in relief on the emphysematous parenchyma. An opaque bilateral chain of cervical ganglions showed. The apices showed clearly upon respiration, the right a little darker. Diminution of the extent of the movement of the right diaphragm. This multitude of punctiform shadows, so opaque and so regularly distributed without predominence at apices seemed more like anthracosis, but the man's profession made that seem unlikely. Questioning showed that in his work however as a joiner he had been repairing coal wagons for over six years and had breathed much of the coal dust. His symptoms and treatment heretofore had been directed toward a possible intestinal disorder. He had lost 10 kilos in two years and sometimes expectorated. Sputum negative. Previous lack of respiratory trouble and negative auscultation made the explanation of the lung appearance as healed tuberculosis seem improbable. The case is cited merely to report an observation of pulmonary trouble whose discovery was due entirely to the radiological examination. SKINNER.